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ORIGINAL ARTICLES.

I.—The Pigmy Hippopotamus of Cyprus.

By Dorothea M. A. Bate.

(PLATE XV.)

THE accompanying Plate represents a restoration of the skeleton of *Hippopotamus minutus*, Blain., which has lately been completed in the Geological Department of the British Museum (Nat. Hist.). The vertebral column and limbs are almost entirely composed of the actual bones, while the model of the skull has been built up according to the various parts obtained separately. No ribs were preserved in their entirety, neither were perfect specimens of the scapulæ or innominate bones procured. A large amount of material, including that from which the reconstruction of this skeleton has been made, was brought from Cyprus as the result of excavations carried on there by me at different times in 1901–2. The specimen was mounted and the skull modelled with great skill by Mr. F. O. Barlow, Formatore in the British Museum (Nat. Hist.).

As already recorded,[1] a number of Pleistocene deposits containing remains of this pigmy hippopotamus were discovered, five of which were situated in caves in the sea cliffs of Cape Pyla, which has a coastline of about five miles. In one of these, which is known as that of Haghios Saronda, the ossiferous breccia attains a thickness of seven feet, while indications are not wanting to suggest the belief that originally it was of even greater dimensions. In the other caves in the vicinity remains were present in much smaller quantities, this being in most cases evidently partially the result of incursions of the sea subsequent to their deposition. Seven other deposits occur on the south side of the Kerynia Mountains, all within a distance of a few miles, and are situated in low and insignificant cliffs which lie parallel with the axis of the range. Owing to the Upper Eocene formation overlapping the limestone to a greater

[1] Trans. Royal Soc. B., vol. 197 (1904), pp. 347–8.

extent on the northern slopes, this secondary cliff-line is absent on that side, which may account for the fact that no osseous remains were found or heard of on the seaward aspect of these hills.

It has been previously noted[1] that several of the deposits found in the north of the island are now no longer enclosed in caves, the walls and roofs of which have partially or entirely disappeared, probably on account of the very rapid atmospheric erosion which takes place in barren limestone districts in this climate.[2] In each of these, with one exception, there is at least one cave-wall still remaining. The exception is found in that of Haghios Chrysostomos, below the peak of Buffa Vento, which is more isolated from the main mountain mass than any of the others, and is situated in an irregular line of limestone rocks which crest a spur projecting into the overlying formation, which is locally known as the "Hummocks." Herr Alfred Bergeat, who studied the geology of Cyprus, mentions, in a paper published in 1891,[3] the mammalian remains near the monastery of Haghios Chrysostomos, which he considers occur, not in a cave-deposit, but in a breccia[4] of large extent. This opinion was probably due to the almost entire disappearance of the limestone cliff-line which formerly rose above the Kythræan formation, but both the presence of very similar examples in the vicinity, and also the stalagmitic nature of the deposit, which was demonstrated during the excavations made here, appear to leave no doubt as to its original deposition in a cavern.

The finding of the remains of this the smallest of the Hippopotami proved, as Dr. Forsyth Major has already pointed out,[5] to be the re-discovery of an almost forgotten species, first noticed by Cuvier[6] as long ago as the early part of last century, though the locality from which it came was not previously known. Although adding to the number of the pigmy Hippopotami of the Mediterranean islands, *H. minutus* rather unexpectedly proves to have apparently little affinity with these, but to be instead more closely allied to the still surviving Liberian species, which has been considered by several authorities, notably the late Sir William Flower,[7] to be sufficiently distinct to form a separate genus (*Chœropsis*), in which the Cypriote form would now probably have to be included, for, as Dr. Forsyth Major anticipated,[8] the further material obtained since the publication of his paper has shown it to be likewise tetraprotodont.

[1] Op. cit., p. 348.

[2] The same phenomenon has been found to occur among the Pleistocene cave deposits of Crete. See Geol. Mag., Dec. V, Vol. II, May, 1905, pp. 193–202.

[3] "Zur Geologie der Massigen Gesteine der Insel Cypern": Tschermak mineralogische und Petrographische Mittheilungen, Band xii (1891), pp. 278–9.

[4] Included in the Kythræan Series of Messrs. Bellamy & Jukes-Browne. See "The Geology of Cyprus," W. Brendon, Plymouth, 1905.

[5] Geol. Mag., Dec. IV, Vol. IX, May, 1902, pp. 198–9, and Proc. Zool. Soc., 3rd June, 1902, pp. 107–111.

[6] "Ossements Fossiles," 2nd ed., i, pp. 322–331 (1821).

[7] Proc. Zool. Soc., 1887, p. 612.

[8] Proc. Zool. Soc., 3rd June, 1902, pp. 107–111.

On comparing the mounted skeleton of *H. minutus* with that of *H. liberiensis*,[1] it was found that in height and antero-posterior length they agree very closely: the height at the withers in each case being about 2 feet $2\frac{3}{4}$ inches, and the length of the vertebral column (along the ventral curve) about 4 ft. $6\frac{1}{2}$ ins. These measurements are, however, if taken by themselves, decidedly misleading, for, in spite of this apparent similarity in size, the Cypriote species has a much smaller skull, must have been longer in the leg, and altogether the slighter animal of the two. This is especially remarkable in the bones of the limbs and feet, which, when compared, are found to be all noticeably very much more slender in *H. minutus* than in the Liberian species. The same diminutiveness also obtains in the dentition: the antero-posterior length of the upper cheek teeth of one side, taken from specimens in a similar stage of wear, is in *H. liberiensis* 142 mm. and in *H. minutus* 132 mm. Three considerably worn molars in a right mandibular ramus of the latter measure antero-posteriorly 77 mm., while the space occupied by the corresponding, though less abraded, teeth of *H. liberiensis* is 85 mm. In the molars from Cyprus there is even less approach than in those of *H. liberiensis* to the trefoil pattern so characteristic of the worn teeth of the larger Hippopotami, and it may also be mentioned that the upper canines of the West African species are so deeply grooved that the surfaces of wear become practically bilobed in outline, whereas in those of the Cypriote race they are as indicated in Fig. 1, p. 244. The width of the palate is, relatively speaking, similar in the two species.

Dr. Forsyth Major has pointed out[2] one or two peculiarities in the skull of *H. minutus*, and we may add that the outline of its anterior half, when viewed from above, is more regular and uniform than is the case in that of *H. liberiensis*, owing to the maxillæ being less constricted and the premaxillæ further extended and more closely connected with the anterior portion of the maxillæ as shown in Figs. 2 & 3, p. 244, this being especially noticeable when the two skulls are seen side by side. The comparative length of those borders of the maxillæ which adjoin the nasals is considerably greater in *H. minutus* than in the recent pigmy species. Another striking difference is that in the former the upper surface of the skull between the orbits is slightly concave, this hollowed appearance being intensified by the projection of the post-orbital processes of the frontals, which in a slight degree assume the tubular form so conspicuous in *H. amphibius*, but which seems to be altogether absent in *H. liberiensis*.

Darwin has declared[3] that a luxuriant vegetation is not necessary for the maintenance of large species of mammals, but in that case undoubtedly an extensive tract of country must be available to contribute to their support. It is pretty generally supposed that many of the small forms found in islands are the direct result of

[1] Presented to the National Collection by Dr. Büttikofer in 1887.
[2] Proc. Zool. Soc., 1902, pp. 107–111.
[3] "Voyage of the Beagle," 12th ed., Ward, Lock, & Co. (1897), p. 98, etc.

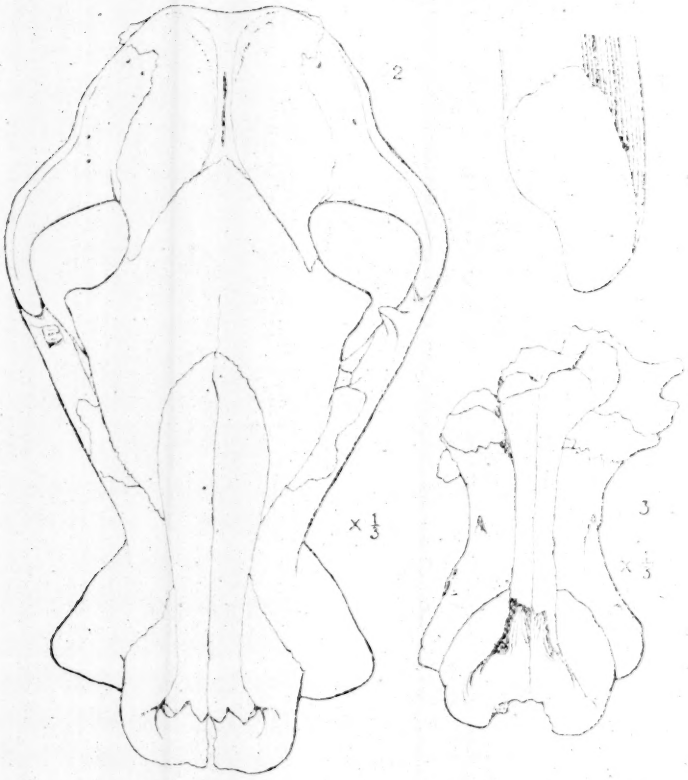

Fig. 1.—Worn surface of left upper canine of *Hippopotamus minutus*, Blainv. Nat. size.

Fig. 2.—Skull of *H. liberiensis*, after Leidy.[1] One-third nat. size.

Fig. 3.—Imperfect skull of *H. minutus*, after Dr. C. I. Forsyth Major.[2] Reduced to one-third nat. size.

[1] Journ. Acad. Nat. Sci. Philadelphia, 1853, ser. II, vol. ii, pl. xxi, fig. 2.
[2] Proc. Zool. Soc., June, 1902, pl. x, fig. 5.

isolation in a limited area by the sea and the consequent shortage of suitable food. On the other hand, pigmy species are not necessarily found in a restricted island habitat, as proved at the present day by the existence of *H. liberiensis*, and perhaps Prjevalsky's Horse might also be cited as an example of this. However, in both these it seems most probable that their diminutive size is rather a primitive than a highly specialised characteristic, and it also seems likely that the same may be true to a great extent in the case of the Cypriote Hippopotamus; the isolation of this last in an island may rather have been chiefly the means of preserving a survivor of an earlier age. As already mentioned, some of the primitive characters, both in the pattern of the teeth and in the structure of the skull of this species, have been noted by Dr. Forsyth Major.[1]

To satisfactorily account for the extinction of the pigmy Hippopotamus and Elephant of Cyprus is a task of extreme difficulty, as there seems to be no evidence that either still existed contemporaneously with man, and, on the other hand, in earlier historical times the island was famed and coveted by different nations, chiefly on account of its great fertility and the extent of its forests. This extinction appears all the more inexplicable when we consider that it must have taken place, comparatively speaking, not so very long after the specialisation in size had been accomplished, for, according to Messrs. Bellamy and Jukes-Browne,[2] Cyprus was still connected with the mainland in early Pleistocene times, since which period *Elephas cypriotes*, at all events, would apparently have attained its later minute proportions. Torrential inundations and other destructive agencies have been suggested as the ultimate reason for the extermination of some of the species peculiar to the Mediterranean islands, and this may be true in some instances, possibly in Malta, but in Cyprus there seems to be no indications of the occurrence of such violent phenomena during the Pleistocene period. It is more likely that some climatic change, and its consequent alteration of the vegetation, was the indirect cause of the disappearance of this pigmy Hippopotamus, which, belonging to an ancient and effete race, was unable in a new direction to "undergo sufficiently rapid variation to enable it to avoid getting so far out of harmony with its surroundings that further existence became impossible."[3]

[1] Op. cit.

[2] See Key to Geological Map of Cyprus, p. 15 (by the former), London, Stanford, 1905; and these two authors on the Geology of Cyprus, Brendon & Son, Plymouth, 1905, pp. 55–6, and fig. 9. With reference to this last, it is interesting to find that Bishop Graziani, writing early in the seventeenth century, says of Cyprus: "'Tis thought she was heretofore a peninsula joining that side of Asia, being separated by the violence of a flood" ("The Sieges of Nicosia and Famagusta," edited by Claude Delaval Cobham, London, 1899).

[3] Dr. C. W. Andrews, "Some Suggestions on Extinction": GEOL. MAG., Dec. IV, Vol. X, January, 1903, p. 2.

II.—Fossil Echinoidea from Sinai and Egypt.

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(PLATE XI.)

(*Concluded from the May Number, p. 227.*)

Order ATELOSTOMATA.

Suborder *ASTERNATA.*

Family NUCLEOLITIDÆ.

1. Nucleolites waltheri (Gauthier), 1900.

Echinobrissus waltheri, Gauthier, in Fourtau: Notes E'ch. foss. Egypte, Cairo (1900), p. 21, pl. I, figs. 8–10.

Distribution.—"Santonian": Berak el Gazal, near Abu Roash (Fourtau). "Eocene": Abu Roash district. L 1379. Coll. H. J. L. Beadnell, Esq. A young broken specimen, east end of the Cretaceous area, near Abu Roash village. I 3796. Coll. H. J. L. Beadnell, Esq.

2. Nucleolites daglensis (Gauthier), 1889.

Echinobrissus daglensis, Gauthier, 1889: E'ch. foss. Sud Hauts-Plateaux Tunisie, p. 41, pl. ii, figs. 24–26.

Distribution.—Cenomanian, "and perhaps also Lower Turonian": Southern Tunis. Marls: lower half of Jebel el Araba, Wadi el Araba, south-westward of Camp 23. L 4120. Coll. by the late T. Barron, Esq. Jebel um Raiyig, north-eastern Sinai. L 3481. Collected by Dr. W. F. Hume.

Dimensions:

					daglensis (Gauthier).					*luynesi* (Lartet's figure).
	mm.	mm.		mm.	mm.	mm.	mm.		mm.
Length ...	19·5	19	...	13	14	16	19	...	18
Breadth ...	18	17	...	10	11·5	13	16	...	15
Height ...	9	8	...	6	7	9	11	...	9·5

It is necessary to compare this species with *N. luynesi*, Cott.,[1] from Mt. Hor, which differs by the more undulating lower surface, and the more anterior position of the highest point in the test.

3. Nucleolites gibbosa (Peron & Gauthier), 1879.

Echinobrissus gibbosus, Peron & Gauthier: E'ch. foss. Algér., fasc. 5 (1879), p. 148, pl. x, figs. 1–4.

The collection includes three specimens, which agree most closely with the above species; but they appear to me to be possibly only variations of *N. daglensis.*

[1] Cotteau, E'ch. foss. recueillis . . . Lartet . . . voyage . . . duc de Luynes. Bull. Soc. géol. France, ser. II, vol. xxvi (1869), p. 535, fig. p. 534. Lartet: Explor. géol. Mer Morte (1877), p. 153, pl. xiii, figs. 15–19.

Distribution.—Middle Cenomanian: Algeria (Bou Saada). Cretaceous Marls: lower half of Jebel el Araba, Wadi el Araba, south-west of Camp 23. L 4120. Collected by the late T. Barron, Esq. Jebel um Raiyig, north-eastern Sinai. L 3481. Collected by Dr. W. F. Hume.

4. Nucleolites meslei (Peron & Gauthier), 1881.

Echinobrissus meslei, Peron & Gauthier, 1881: Ech. foss. Algér., fasc. 7, p. 157, pl. xvi. figs. 7–12.

Distribution.—East end of Abu Roash village. I 3791. Collected by H. J. L. Beadnell, Esq. Fragment from the same locality. I 3796. Collected by H. J. L. Beadnell, Esq.

This collection of 18 specimens of a large *Nucleolites* includes two types; the common type agrees in all respects with the above species except that it is a little lower, as shown by the following table:—

Dimensions:

	I 3791. *a.*	I 3791. *b.*	I 3791. *c.*	Average of the three.	*fide* P. & G.	
	mm.	mm.	mm.	mm.	mm.	mm.
Length	31·5	28·5	31	... 30·33	... 31	30
Width	28	25·75	27·5	... 27·08	... 28	25
Height	14	14	14·5	... 14·17	... 15	15
Ratio of length to width	—	—	—	... 100 : 89	... 100 : 90	100 : 83
Ratio of length to height	—	—	—	... 100 : 46·5	... 100 : 48	100 : 50

Some of the specimens (as number *a* in the above table) are somewhat longer and more pointed at the posterior end; but this seems to me due to the fold on the posterior margin being produced backward instead of downward.

Order STERNATA.

Family SPATANGIDÆ.

Section **Prymnadetinæ.**

HEMIASTER, Desor, 1847.

1. Hemiaster pseudo-fourneli, Peron & Gauthier, 1878.

Ech. foss. Algér., fasc. 4 (1878), p. 113, pl. iv, figs. 5–8.

Distribution.—Cenomanian: Algeria, Batna, etc.; southern side of Jebel Ejjibi, near Ain el Hudhera, Sinai. L 3480. Collected by Dr. W. F. Hume. Cephalopod bed, head of Wadi Ethal. L 3918. Collected by the late T. Barron, Esq.

Dimensions:

	L 3480.	Peron & Gauthier's (figured specimen).
Length	31·5 mm.	... ... 33 mm.
Width	30·5 mm.	... ... 31 mm.
Height	22 mm.	... ... 23 mm.

2. Hemiaster fourneli, Deshayes.

For synonymy, etc., see Fourtau: Révision, p. 631.

Coptosoma abbatei beds, Abu Roash. Three broken specimens. Collected by Mr. Beadnell (I 3787).

3. Hemiaster blanckenhorni, Gauthier, 1900.

In Fourtau: Notes E'ch. foss. E'gypte, p. 23, pl. i, figs. 11, 12.

I 3796 includes one crushed specimen from the eastern end of the Cretaceous area, near Abu Roash village.

4. Hemiaster africanus, Coquand, 1862.

Géol. Pal. S. Prov. Constantine: Mém. Soc. E'mul. Provence, vol. ii, p. 217, pl. xxv, figs. 10–12.
Cotteau, Peron, & Gauthier: E'ch. foss. Algér., fasc. 6 (1879), p. 58.

Distribution.—Turonian: Batna, etc., Algeria. Cenomanian: Cephalopod bed, head of Wadi Ethal, Sinai. L 3918. Collected by the late T. Barron, Esq.; also side of Jebel Ejjibi, near Ain el Hudhera. L 3480.

5. Hemiaster nicaisei, Coquand, 1862.

Géol. Pal. S. Prov. Constantine: Mém. Soc. E'mul. Provence, vol. ii, p. 326, pl. xxv, figs. 22, 23.

Distribution.—Cenomanian: Algeria (Aumale, Berouaguiah). Cenomanian (?): Cephalopod bed, head of Wadi Ethal, Sinai. L 3918. Collected by the late T. Barron, Esq.

6. Hemiaster chauveneti, Peron & Gauthier, 1878.

E'ch. foss. Algérie, fasc. 4, p. 135, pl. viii, figs. 1–5.

Distribution.—Cenomanian: Algeria. Marls at Wadi Ragga, Sinai. L 4223. Collected by the late T. Barron, Esq.

7. Hemiaster saadensis, Peron & Gauthier, 1878.

E'ch. foss. Algérie, fasc. 4, p. 125, pl. vi, figs. 1–4.

Distribution.—Cenomanian—Algerian: Bou Saada. Marls at Wadi Ragga, Sinai. L 4223. Collected by the late T. Barron, Esq.

8. Hemiaster jullieni, Peron & Gauthier, 1878.

E'ch. foss. Algérie, fasc. 4, p. 124, pl. v, figs. 8–11.

Distribution.—Cenomanian (Rhotomagian): Algeria (Krenchela). Marls at Wadi Ragga, Sinai. L 4223. Collected by the late T. Barron, Esq.

9. Hemiaster battnensis, Coquand, 1862.

Géol. Pal. S. Prov. Constantine: Mém. Soc. E'mul. Provence, vol. ii, p. 218, pl. xxvi, figs. 6–8.
Synonymy, see Cotteau, Peron, & Gauthier: E'ch. foss. Algérie, fasc. 4 (1878), p. 118.

Distribution.—Cenomanian: Algeria. Cephalopod bed, head of Wadi Ethal, Sinai. L 3918. Collected by the late T. Barron, Esq.

LINTHIA, Merian, 1853.

1. ? Linthia roachensis (Gauthier), 1900.

In Fourtau: Notes E'ch. foss. E'gypte, p. 24, pl. i, figs. 13–15.
Linthia roachensis, Dacqué, 1903: Palæontogr., vol. xxx, p. 357.
Hemiaster lusitanicus, de Loriol, 1883: ibid., vol. xxx, p. 39.

Three broken specimens, labelled "Eocene," Abu Roash (I 1379), are not unlikely to be this species, but sand-polishing has removed all the tubercles, and they are badly crushed.

2 I 3796. Two specimens, probably of the same form, but both differently crushed. The peripetalous fasciole is distinct, but not the lateral; otherwise they might be *L. roachensis*.

2. Linthia oblonga (d'Orbigny), 1854.

Periaster oblongus, d'Orbigny, 1854: Pal. franç., Terr. crét., vol. vi, p. 275, pl. 900.
Linthia oblonga, Peron & Gauthier, 1880: Ech. foss. Algérie, fasc. 6, p. 79.
Linthia oblonga, Fourtau, 1899: Rév. Ech. foss. Egypte, Mém. Inst. égypt., vol. iii, fasc. 8, p. 631.
Linthia oblonga, R. B. Newton, 1904: *L. oblonga* from Sinai, Geol. Mag. (1904), pp. 441–445, Pl. XV.

The collection of Spatangoids includes a large series from the Cephalopod bed in Wadi Ethal (L 3918), the determination of which has been the most difficult problem in dealing with this collection.

I have not adopted the easiest course in dealing with them, though that, perhaps, would be the right one. That course would be to 'lump' most of them in one species and label it *Linthia oblonga* (Orb.), and also include therein *Hemiaster luynesi*, Cott., and some Algerian echinoids described as *Hemiaster*.

The specimens from Wadi Ethal show the peripetalous fasciole very clearly; and in some of them there are obscure traces of the lateral fasciole. The latter specimens can be safely identified as *L. oblonga*, as has been done by Mr. R. B. Newton. But the majority of the specimens have no lateral fasciole. In many the tuberculation is so well preserved and the peripetalous fasciole is so distinct, that the absence of the lateral fasciole is not due to imperfect preservation. If these specimens are to be included in *Linthia*, the diagnosis of that genus must be amended to the effect that the lateral fasciole may be absent from many specimens of a species. In that case there is no constant difference between *Linthia* and *Hemiaster*.

This conclusion may be the right one, for there is a remarkable parallelism between species of *Hemiaster* and of *Linthia*. Thus the *Hemiaster luynesi* and *H. meslei* and *H. pseudofourneli* may be forms of *L. oblonga* without a recognizable lateral fasciole. *H. pseudofourneli* would be a somewhat thick variety; but the following dimensions given by Newton show that there is a considerable variation in the form of *L. oblonga*, his second specimen being decidedly narrower in proportion to its width than the others:

Dimensions:

Length	...	31 mm.	...	28 mm.	...	30 mm.
Width	...	27 mm.	...	21 mm.	...	27 mm.
Height	...	20 mm.	...	18 mm.	...	19 mm.

[1] Cotteau, Ech. foss. voyage duc de Luynes: Bull. Soc. géol. France, ser. II, vol. xxvi (1869), p. 535, fig. p. 534. Better figures are given by Lartet: Explor. géol. Mer Morte (1877), pl. xiv.

The relations of those species of *Hemiaster* and *Linthia* having forms similar to *L. oblonga* can only be satisfactorily determined by a careful study of the specimens from the Mediterranean Cenomanian and Turonian series. This study would show whether the many accepted species of *Hemiaster* in that fauna are mutations or individual variations.

Distribution.—Cenomanian and Turonian: Algeria, Palestine, near Suez, Cephalopod bed, head of Wadi Ethal. L 3918. Collected by the late T. Barron, Esq.

List of Mesozoic Echinoids described in the foregoing paper, giving their Distribution in the various localities.

	Egypt.	Sinai.						
	Abu Roash.	Jebel Egjibi.	Jebel Gunnech.	Jebel um Rafyg.	Wadi Ethal.	Jebel el Araba.	Wadi Raggat.	
Heterodiadema bigranulatum, n.sp.	...		×					Cenomanian.
Acanthechinopsis humei, n.sp....	...		×					Cen.
Micropedina bipatellis, n.sp. ...	...		×	×				Cen.
Cyphosoma headnelli, n.sp. ...	East end							
Thylechinus quincuncialis, n.sp.	...				×			
T. trigranulatus, n.sp.	...				×			
Coptosoma abbatei (Gauth.) ...	E. end.							With *H. fourneli*.
C. gunnechensis, n.sp.	...		×					Turonian.
Holectypus cenomanensis, Guér.	...			×		×		Cen.
H. turonensis (Desor)	...				×		×	Tur.
H. larteti (Cott.)	...				×			Mt. Hor.
? *Galerites thomasi* (P. & G.) ...	...				×			Cen. ?
Nucleolites waltheri (Gauth.) ...	E. end.							
N. daglensis (Gauth.)	...			×		×		Cen. & ? Tur.
N. gibbosa (P. & G.)	...			×		×		Cen.
N. meslei (P. & G.)	E. end.					Ceph. bed		Cen.
Hemiaster pseudo-fourneli, P. & G.	...	×			×			Cen.
H. fourneli, Desh.	E. end.							With *C. abbatei*.
H. blanckenhorni, Gauth. ...	E. end.							
H. africanus, Coq.	...	×			×			Turonian.
H. nicaisei, Coq.	...				×			Cen.
H. chaureneti, P. & G. ...	...						×	Cen.
H. saadensis, P. & G.	...						×	Cen.
H. jullieni, P. & G.	...						×	Cen.
H. battnensis, Coq.	...				×			Cen.
? *Linthia roachensis* (Gauth.) ...	With *N. waltheri*.							
L. oblonga (Orb.)	...				×			Cen. & Tur.

II. EOCENE AND MIOCENE.

Order ATELOSTOMATA.

Suborder *ASTERNATA.*

Family CASSIDULIDÆ.

Subfamily *ECHINOLAMPINÆ.*

ECHINOLAMPAS, Gray, 1825.

1. ECHINOLAMPAS GLOBULUS, Laube, 1867.

Beitr. Kennt. Ech. vicent. Tert.: Sitz. Akad. Wiss. Wien., vol. lvi, 1, p. 239; and 1868, Denk. Akad. Wiss. Wien., vol. xxix, p. 4, pl. iv, fig. 5.

This species has been twice recorded by M. de Loriol-le-Fort, who, in the later of his excellent accounts of the species, considerably reduced its dimensions.

In his Monograph of 1880[1] he records the length as from 25 to 60 mm., and in that of 1883[2] as from 12 to 26 mm. These specimens (I 1379) from the Eocene of Abu Roash fully agree with the account and figures in his earlier paper. The specimens are of the larger size, 57 mm. long by 41 mm. broad by 34 mm. high. They are nearest, among the larger species, to *E. libycus*, Lor.[3]

2. ECHINOLAMPAS AFRICANUS, de Loriol, 1880.

Op. cit., p. 90, pl. iii, fig. 1; pl. iv, figs. 5, 6; and 1883, op. cit., p. 23, pl. vii, fig. 1.

The following specimens from the Eocene of Sinai were collected by the late Mr. Barron :—

L 4148. Three worn specimens. Nummulite beds, Jebel Wagra, Wadi Feiran, Sinai.

L 3582. Three worn specimens. Top of Nummulite bed, Wadi Khadahid, Sinai.

L 3578. Two worn specimens. Nummulite bed, Wadi Abyad, Sinai.

L 4175. One worn specimen, crushed with depressed petals. Nummulite bed, Jebel el Araba, Wadi el Araba.

Dimensions :

	L 4148.	L 3582.	A crushed specimen. L 3582.	L 3578.	*Fide* De Loriol.
Length ...	84 mm.	74 mm.	90 mm.	86 mm. ... 96 mm.	75 to 100 mm.
Width ...	73·5 mm.	62 mm.	85 mm.	72 mm. ... 78 mm.	—
Height ...	42 mm.	38 mm.	53 mm.	44 mm. ... ?	—
Ratio of length to width ...	100 : 87·5	100 : 84	100 : 95	100 : 84 ... 100 : 81	100 : 85 to 88
Ratio of length to height ...	100 : 50	100 : 51	100 : 59	100 : 51 ... —	100 : 48 to 62; average 50.

[1] P. de Loriol: Mon. Ech. numm. Egypte, Mém. Soc. Phys. Nat. Hist. Genève, vol. xxvii (1880), p. 98.
[2] P. de Loriol: Eoc. Echin. Ægypt., Palæont., vol. xxx (1883), pt. 2, p. 27.
[3] Ibid., p. 31, pl. v.

3. Echinolampas fraasi, de Loriol, 1880.

Op. cit., p. 92, pl. v, fig. 1; 1883, op. cit., p. 22, pl. vi.

One specimen with specimens of *Echinolampas africanus*, from the top of the Nummulite beds, Wadi Khadahid, Sinai. L 3582. Collected by the late T. Barron, Esq.

Dimensions:

		Fide de Loriol.
Length	88 mm. (?)	92 mm.
Width	85 mm.	—
Height	55 mm.	—
Ratio of length to width ...	100 : 96 (?)	100 : 84
Ratio of length to height ...	100 : 60 (?)	100 : 67

4. Echinolampas feiranensis, n.sp. (Pl. XI, Figs. 11–14.)

From the locality of Wadi Feiran.

Diagnosis.—Test: the front half is subcircular, but the anterior margin is somewhat flattened; the two sides are well rounded; the posterior end is produced to a blunt rostrum. Hence the slope is subpentagonal. The margin of the actinal surface is flat, but the peristome is in the middle of a broad, fairly deep depression. The upper surface is high; the apex is very excentric anteriorly, and the front slopes steeply forward.

Ambulacra: the petals are long, and reach nearly to the margin of the test. The petals are well developed, and the interporiferous areas are tumid.

Periproct on the rostrum.

Dimensions:

	L 4204 (fig. *a*).					De Loriol. 1880.	1880.
Length ...	38·5 mm.	37 mm.	29 mm.	30 mm.	36·5 mm.	17–30 mm.	18 mm.
Width ...	33 mm.	35 mm.	27·5 mm.	28 mm.	33 mm.		
Height ...	21 mm.	13 mm.	14·5 mm.	11 mm.	17·5 mm.		
Ratio of length to width ...	100 : 91		100 : 95		90	100 : 87–98	100 : 94
Ratio of length to height ...	100 : 54		100 : 50		100 : 48	100 : 56–78	100 : 61
Distance of centre of apex from anterior margin: de Loriol (fig. 4)	14 mm.		10 mm.		14 mm.	12 mm. Length of test, 27·5	
Ratio of length to that distance	100 : 36·3		100 : 34·5		100 : 38·3	100 : 43·6	

Distribution.—Limestone, probably Miocene: south of Wadi Feiran, Sinai. L 4204. Collected by the late T. Barron, Esq.

Figures.—Pl. XI, Figs. 11–14. Fig. 11, a specimen from above, nat. size; Fig. 12, the same specimen from the side, nat. size; Fig. 13, small specimen from the side, nat. size; Fig. 14, base of a third specimen, nat. size.

Affinities.—This species is most nearly allied to *E. crameri*, de Lor.,[1] from which it differs by the subtumid petals, the flatter form, and more anterior position of the apical disc.

The other near ally of *E. feiranensis* is *E. gonjoni*, Pomel,[2] from the Lower Eocene of Tunis; but in the form of the peristome that species is much nearer to *E. crameri* than to the new species.

5. Echinolampas aff. insignis, Pomel.

H 2191. Two broken specimens. Near Dara Hill, west of Dara, "close to Miocene, on Eocene and Cretaceous." Eastern side of the Red Sea Hills. Collected by the late T. Barron, Esq.

Two very broken, crushed specimens, length 118 mm., width 117 mm., height 41 mm. (crushed).

III. PLEISTOCENE.

Subclass *REGULARIA ENDOBRANCHIATA.*

Order CIDAROIDA.

Family CIDARIDÆ.

Phyllacanthus imperialis (Lamk.).

Raised beach, Dahab. L 3516.

Subclass *REGULARIA ECTOBRANCHIATA.*

Suborder *ECHININA.*

Family TRIPLECHINIDÆ.

Echinus verruculatus (?).

In Pecten bed, Upper Coral Terrace between Nebk and Sherm, N.E. Sinai. L 4324.

Toxopneustes pileolus (Lamk.).

Raised beach, 20 feet above sea-level. Gharib Lighthouse. J 2058–98.

Family ECHINOMETRIDÆ.

Echinometra lucunter (Leske).

Raised beach, 20 feet above sea-level. Gharib Lighthouse.

Heterocentrotus mammillatus (Leske).

Shore at Dahab. L 3524.

Many spines. Raised beach, 80 feet above sea-level. Camp 6, Wadi Gueh. K 1558.

[1] De Loriol, 1880: op. cit., p. 100, pl. vi, figs. 4–10. 1883: op. cit., p. 32, pl. iii, fig. 8.

[2] See e.g. Gauthier, Ech. foss. recueillis en 1885 et 1886 dans Hauts-Plateaux Tunisie par Thomas: Explor. Sci. Tunisie, Paris, 1889, p. 94, pl. vi, figs. 12–14.

Raised beach at Dahab. L 3516.
Raised beach, north of Koseir. J 2121–38.
Raised beach, 20 feet above sea-level. Gharib Lighthouse. J 2058–98.
Lower raised beach, east of Jebel Esh. K 2155.
Raised beach, Camp 4, Wadi Hamrawein. J 1638.
Raised beach, Camp 5, Wadi Gueh. K 1615.

Subclass *IRREGULARIA*.

Order GNATHOSTOMATA.

Suborder *CLYPEASTRINA*.

Family FIBULARIIDÆ.

Fibularia volva, Ag.
Raised beach, 20 feet above sea-level. Gharib Lighthouse. J 2058–98.

Family LAGANIDÆ.

Laganum depressum, Lesson.
Raised beach, Camp 4, Wadi Hamrawein. J 1638.
Pecten bed in cliff between Nebk and Sherm. L 3539.
Raised beach, east of Jebel Esh. J 2154.

Family SCUTELLIDÆ.

Echinodiscus sp. (too fragmentary for description).
"Beach deposits," north side of Wadi Feiran. L 4288.

Family CLYPEASTRIDÆ.

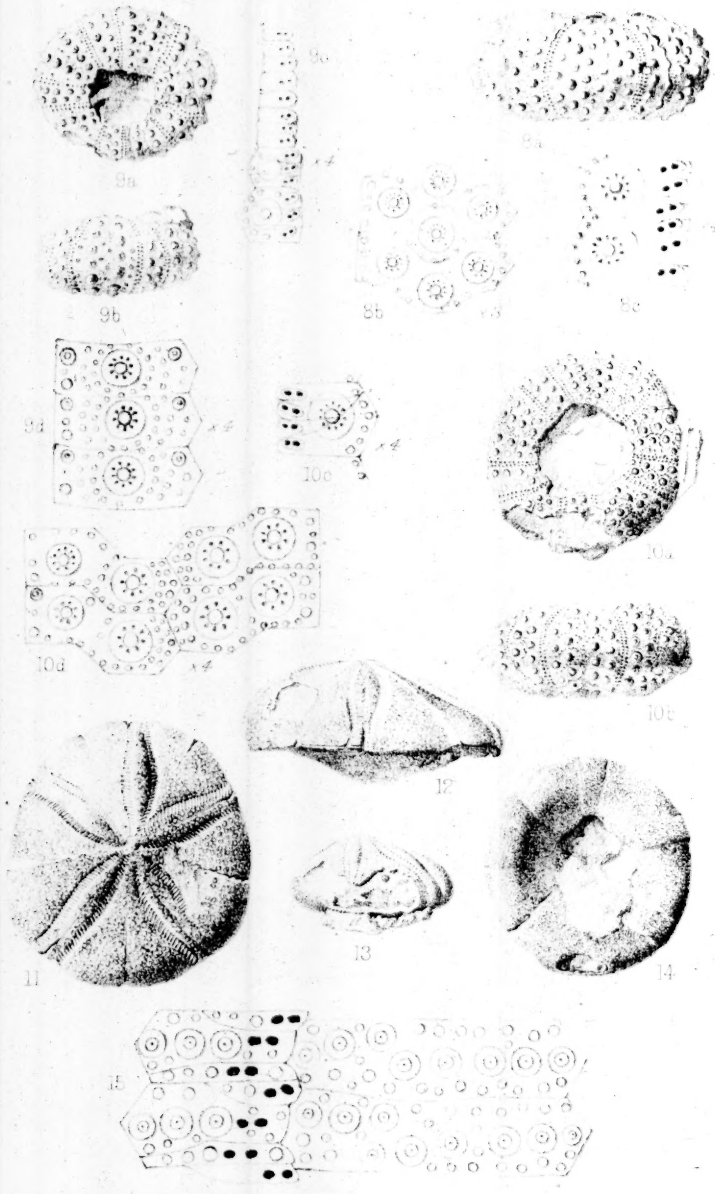
Clypeaster scutiforme (Gmel.).
Raised beach, No. 2, west of Camp 7, Wadi Abu Shigeli, north of Kosseir. J 1614.
Raised beach, near Dahab, E. Sinai. L 3494.
Third raised beach between Nebk and Sherm, Sinai. L 3538.

Clypeaster humilis (Leske).
Camp 4, Wadi Hamrawein. J 1638.

Clypeaster aff. humilis.
Raised beach, Gaa, Camp 23, side of Jebel el Araba. L 3634.

Clypeaster sp. young.
Raised beach, Camp 4, Wadi Hamrawein, near Qosseir. J 1638.

Clypeaster sp.
Raised beach, north of Qosseir. J 2121–38.
Pecten bed, in cliff between Nebk and Sherm. L 3539.
"Beach deposits," north of Camp 7, south of Wadi Feiran, Sinai. L 4204. Probably fragment of a Miocene species.



E. Drake del. et lith. West, Newman imp.

Fossil Echinoidea from Sinai & Egypt.

Order ATELOSTOMATA.

Brissus carinatus (Lamk.).

Raised beach, north of Qosseir. J 2110.

Brissus (?) carinatus (Lamk.).

Abu Shigeli, 560 feet above sea-level. J 1624.
Wadi Abu Shigeli, 380 feet above sea-level. K 1660.

Indeterminable cast of perhaps a Schizaster, allied to gibberulus, Ag., or perhaps a Brissopsis.

Raised beach, 300 feet above sea-level, Wadi Hamrawein. K 1553.

?Schizaster gibberulus, Ag.

600 feet above sea-level, Camp 4, Wadi Hamrawein. K 1638.

Lovenia elongata (Gray).

Shore, Dahab. L 3524.

EXPLANATION OF PLATE XI.

Fig. 8.—*Thylechinus quinquecialis*, n.sp. Cenomanian: marls at head of Wadi Ethal, Sinai. L 3872. Collected by the late T. Barron, Esq.
8*a*, a specimen from the side. Nat. size.
8*b*, part of the ambitus, showing the plan of the interambulacral tubercles. × 3 diam.
8*c*, two compound ambulacral plates from the same. × 4 diam.

Fig. 9.—*Thylechinus trigranulatus*, n.sp. Cenomanian: marls at head of Wadi Ethal, Sinai. L 3872. Collected by the late T. Barron, Esq.
9*a*, test from below. Nat. size.
9*b*, from the side. Nat. size.
9*c*, upper part of an ambulacrum, showing the structure of the plates. × 4 diam.
9*d*, part of an interambulacrum at the ambitus. × 4 diam.

Fig. 10.—*Coptosoma gunnehensis*, n.sp. Cenomanian (?): Jebel Gunneh, Sinai. L 3506. Collected by Dr. W. F. Hume.
10*a*, *b*, type-specimen from above, and from the side. Nat. size.
10*c*, a compound ambital ambulacral plate. × 4 diam.
10*d*, ambital interambulacral plates. × 4 diam.

Figs. 11–14.—*Echinolampas feiranensis*, n.sp. Miocene: south of Wadi Feiran, Sinai. L 4204. Collected by the late T. Barron, Esq.
11, 12, the type-specimen from above and from the side. Nat. size.
13, a small specimen from the side. Nat. size.
14, base of a third specimen. Nat. size.

Fig. 15.—*Micropedina cotteaui*, Coquand. Ambital plates (after Cotteau).

[Erratum.—In Geol. Mag., May number, p. 227, in Explanation of Plate X, Fig. 3, *Acanthechinopsis humei*, n.sp., is, by an error, printed *A. barroni*, n.sp. It is correctly printed as *A. humei* on p. 219, and also in list of species on p. 250.—Edit. Geol. Mag.]

III.—Some Notes on Archæan Stratigraphy.

By F. P. Mennell, F.G.S.

MUCH has been written concerning the Archæan rocks from a petrographical point of view, but their structural relations have as a rule received little attention. I do not wish to be understood as overlooking the work that has been done in England, and especially in America, of late, and which has added so much to our

knowledge of the older rock groups. But when we come to deal with formations of such high antiquity as those which chiefly concern the geologist in South Central Africa, it becomes evident that we can hope to derive little assistance from the observations that have been made in other quarters of the globe. In the European area there is so great a preponderance of sediments whose nature is obvious, and whose structural relations are only just sufficiently complicated to be interesting, that it is far too common to find the schistose rocks indiscriminately lumped together, with the intrusions that invade them, as "igneous and metamorphic," whereas in an Archæan area the basis of all stratigraphical work (if I may use such a term) must be the distinction between the igneous rocks and those which owe their proximate characters to metamorphism, whatever their origin may be. We find, in fact, that even where much time and labour has been spent over these rocks they have resulted in so much controversy and confusion that the geologist in a region like Tropical Africa finds it necessary to discard most of his preconceived ideas and start to frame new generalisations for himself. And how important it is to have clear ideas on the subject will be realised when it is considered that in some countries nearly all the rock groups are of Archæan age. Indeed, as I have already had occasion to point out,[1] the European area is probably unique in its vast development of sedimentary as compared with igneous and metamorphic rocks. In Africa the stratified formations may almost be looked upon in the same light as the drift deposits of England. They merely form a superficial coating through which the 'basement rocks' of the earth's crust constantly protrude except along the coastal fringe. If we look, for example, at the map accompanying Hatch & Corstorphine's recently issued "Geology of South Africa," we find separate colours used for eight different sedimentary formations, which range from 5,000 to over 25,000 feet apiece in thickness. Only one of these is known to be of pre-Archæan date, and what are now admitted to be the Cape equivalents of the seven remaining groups are all officially classed as Archæan by the Cape Geological Survey, and it is certain that none are pre-Silurian. It is perhaps necessary to remind the reader that the once popular correlation of the Transvaal rocks with the Palæozoic strata of the Cape is, as was first pointed out by the writer two years ago, quite untenable, and is now thoroughly discredited.

It may be that the structure of the Central African metamorphic area is simpler than that of similar regions elsewhere, but it is certain that more light is likely to be thrown on some of the most interesting problems of physical geology by the study of its formations than can be thrown upon these last by the results so far obtained in other countries. This may in part be attributed to the great extent and striking lithological features of some of the principal rock groups, and even more perhaps to the clearness of the exposures. Instead of the irritating little isolated patches

[1] "Geology of South Rhodesia," p. 25.

of rock that we are accustomed to in England, we find miles of almost continuous sections along hill-slopes and stream-beds. Even a comparatively bare tract like the Alps is at a disadvantage owing to its ups and downs, whereas the African tablelands afford almost plane surfaces. The remarkable rocks that we used to puzzle over through the microscope are clearly shown in their relations with the other formations, and we are able to form definite conclusions where before we could but guess. The writer has scarcely passed a day for four years without setting foot on Archæan rocks. And he may place on record his deliberate opinion that there is no greater rarity than a "rock of doubtful origin," if we except, perhaps, a few talcose rocks and others usually occurring around mineral deposits, in whose formation hydrothermal agencies have played a great part. There does not appear to be any problem of this nature that combined field and microscopic observation is not competent to solve. The coarsely crystalline schists which have excited so much controversy are found to have been crystalline from the start, as they appear to be invariably of igneous origin, for it can be proved to demonstration in the majority of cases, and must be accepted as an inevitable inference in the rest. Most gneisses are, in fact, igneous rocks of quite recent date in comparison with the sediments into which they can be seen intrusive. These sediments are rarely of a highly crystalline nature, save along contacts, and show their true characters both in their composition and their field relations. Careful search indeed rarely fails to reveal exposures where they are comparatively free from alteration, and show clearly their sedimentary origin even in hand specimens. The groups which have perhaps been the greatest puzzles in other parts of the world are here quickly reduced to order. The banded gneisses, granulites, etc., whose secret seemed so impenetrable when their field relations were imperfectly understood, are no longer a mystery when we can examine them along bare rock surfaces miles in extent. Some are granites modified by movements in consolidation and the local absorption of particular classes of rock; others are schists modified by contact action and impregnation with granitic material; others, again, can be termed neither igneous nor metamorphic, but may be conveniently classed as 'mixed rocks,' having been formed by the interlamination of igneous and other material due to the 'lit par lit' injection processes which characterise the plutonic masses when we get near their roots.

Among rocks such as we have alluded to, the principles of ordinary stratigraphy have little application. Terms like dip and strike become almost meaningless, and the structural relations of the rocks have to be made out from quite other considerations than superposition. The apparent dip is simply that of foliation, and though the strike often coincides, as pointed out by Judd,[1] with the real direction of the strata, this is by no means always the case, as may soon be found out by the simple experiment of following the apparent strike of a band with well-marked lithological characters

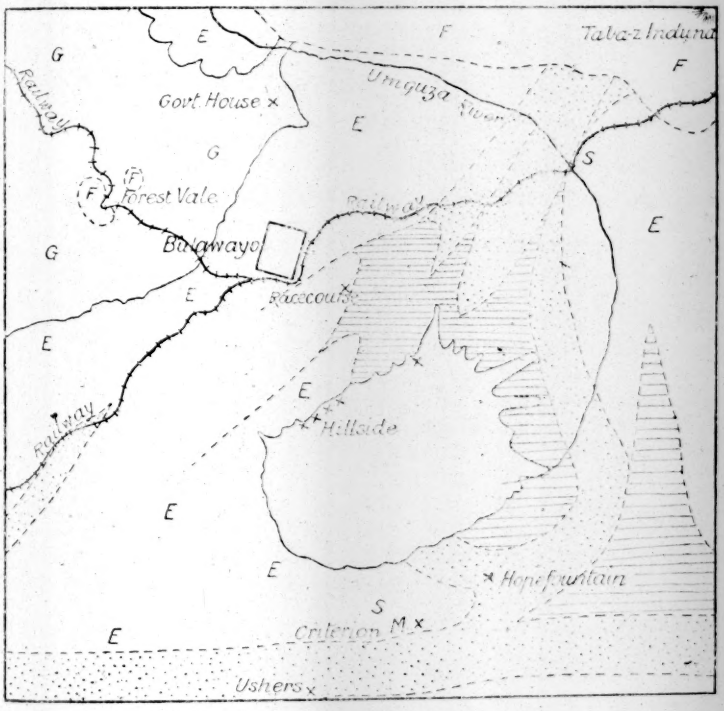
[1] Student's Lyell, p. 549.

Definite evidence of the relative ages of different formations is not often easy to obtain. Even if the dips could be relied upon, they are usually vertical or nearly so. There is one point, however, to which attention may be drawn. A little consideration will show that the great granite masses which are so important a feature of these areas must, as a rule, indicate anticlinal or dome-like structures, and we find in fact that where the dips depart from the vertical they are nearly always away from the granites. Where this is the case the relative distances of the different rocks from the granites may be taken as one of the chief aids in determining the succession. For it stands to reason that the oldest beds will be nearest the axis of elevation marked by the granite. Any indication, however, of marked transgression on the part of the igneous rock, such as dip of the foliation *towards* the latter, or the strike of the schists being directly into it, prevents such a criterion being relied on. I may say, however, that even where the dips are reversed the rocks generally occur in their normal succession, as determined elsewhere. An important point to remember is that metamorphosed igneous intrusions figuring amongst the schists may behave as rocks of any date earlier than their real period of formation. This follows naturally from their protrusion from below, and hence it is very difficult in some cases to distinguish between them and the much older rocks on which some of the schists of sedimentary origin (in which they are intrusive) have been laid down. Their intrusive nature has to be inferred from (1) petrological characters, (2) the way in which they make unexpected appearances among the old sediments, (3) such traces as may survive of contact action produced by them, (4) absence of pebbles derived from them in such conglomeratic beds as may occur.

The last reference to conglomerates reminds us of what an important feature they may be in Archæan stratigraphy. Very few developments of Archæan rocks fail to show important conglomerate beds, and they are simply invaluable as datum-lines. Not only are they readily recognised in the field as a rule, but their pebbles afford most important evidence of their age. Thus the relative ages of the two most important sedimentary series in Rhodesia is at once determined by the fact that one of them, the Conglomeratic series as it may be called, contains numerous pebbles of the other, which I have termed the Banded Ironstone series. The two sets of beds, though of enormous thickness, are folded together in the most intricate manner, and though their order of superposition was originally determined by me solely on the strength of the evidence afforded by their general relative distance from the granite, it is very satisfactory to get the additional proof given by the pebbles.

Even where the granites are transgressive in a marked degree, evidence of the order of succession of the metamorphic rocks may sometimes be obtained from carefully considering their relations to the granite. We may take an actual instance from the neighbourhood of Bulawayo. The figure, representing an area about 18 miles

across, shows the general structure of the schistose rocks round the Hillside intrusion (consisting chiefly of a remarkable type of augite-microcline syenite). The sketch is rather diagrammatic, owing to the lack of any detailed topographical maps, but though the exact outlines of the various groups may require alteration it may be taken as a fair representation of the facts. The dotted areas are covered by the Conglomerate series, and the lined ones by the Banded Ironstones (altered fine mechanical sediments, characterised by a jaspery appearance, and a banding due to the differences in the iron contents of the various layers), while the unshaded portions are occupied by the schists of igneous origin and other rocks. The



Sketch-plan of Hillside Granite Mass, showing relations to the surrounding rocks. Granite-schist boundaries solid, all others dotted. Banded Ironstone, lined; Conglomerate, spotted. F, Forest Sandstone; E, Epidiorite, etc.; S, Chlorite Schists; G, Granite.

east and west trend seen at the bottom of the figure is due to what may be termed the Matopo system of folds, as it resulted in the rising up of the great Matopo granite mass, while above there is seen a tendency to parallelism with the edge of the granite to the

westward. The Hillside intrusion has obviously risen by eating its way upward, and not primarily owing to the folding of the schists, which are not much thrown out of their course in its neighbourhood. But the first impulse must all the same have been due to an incipient fold, and though it is so slight it affords an important clue to the structure of the area. The apparent dip of the beds is vertical, as near as may be, but though this may represent the position on a small scale the *general dip* (or the *true dip*) of the beds cannot be very steep, as may be inferred from the diagram. For slight as has been the disturbance of the beds, the tilting has been sufficient to prevent the conglomerate from anywhere coming into actual contact with the intrusion on the north or east. It is evident from this, first, that the Banded Ironstone is the older rock, and further, since denudation has entirely removed the conglomerate from its surface, even though the uplift has been so slight, that the folds cannot be very sharp. If they were, the conglomerate would not wedge out in the way it does before coming close to the intrusion. On the south side of the intrusion there is probably extensive faulting where the two systems of folds meet, for the Basement schists run as a wedge into the conglomerate, without any intervening Banded Ironstone. This will account for the difference in structure that is shown.

A point of considerable importance in all Archæan areas is the relation of schists and granite. As Professor Bonney points out, the cases of gradation from mica-schist through gneiss into granite are due merely to the fact that a kind of mica-schist is produced through the crushing of gneiss, and the latter itself from the granite.[1] But even this is a rare phenomenon, for true mica-schists are not at all common in my experience, and I know of hardly any so-called gneiss which is not obviously an igneous rock—nearly always a granite which has become somewhat 'streaky' before complete consolidation. To the unaccustomed eye, however, it is not at first by any means a simple matter to determine whether a granite is intrusive or not. I may say that though it was perfectly obvious from the undisturbed condition of the granite, and the much folded state of the surrounding districts near Bulawayo, that the former must be intrusive, I was a long time in bringing to light unquestionable evidence on the point. Indeed, if it had not been for a lucky chance taking me over the magnificent contact section of the Matopo granite, in an out-of-the-way locality near Figtree, it might have been two years instead of only one before I was able to interpret the evidence near Bulawayo. For the evidence is precisely what has led many geologists into recording instances of supposed gradation between schists and granite, or, on the other hand, into denying the intrusive character of the granite. Dr. Hatch, for example, after making a tour through Rhodesia,[2] actually came to the conclusion that the schists were intrusions in the granite (!), though he has since retracted this opinion in consequence of the

[1] Proc. Geol. Assoc., vol. xv, p. 4.
[2] Geol. Mag., 1895, pp. 193, etc.

evidence adduced by me to the contrary.[1] The dome-like structure of the schists round most of the granite masses is readily accounted for on the idea of the greater age of the latter. What has, however, given rise to the greatest confusion is the fact that at their roots granite masses do not show those features which we have learnt to regard as characteristic of intrusion where we have seen them, as is generally the case in Europe, invading normal sediments. Actual dykes are rare, and do not extend far from the main mass of the rock. The characteristic feature of the invasion of crystalline schists is in fact the production by 'lit-par-lit injection' of those very rocks which have aroused the greatest amount of controversy. Once this fact is realised, much becomes clear that before was very far from it. The scantiness of dyke-like protrusions is readily explained. At great depths the formation of open fissures is scarcely possible; eruptive activity is naturally prominent only in the upper part of a mass. The offshoots from the deep-seated portions must corrode a way into the surrounding rocks, or insinuate their material between their laminæ. The last process is the usual one, and even the few large dykes that are seen are mere feeders by which the injection is carried on, and which soon become exhausted in the process. They therefore scarcely ever extend beyond the zone of injection 'lit par lit,' though as this may be over a mile across, that would not prevent them being prominent, and their extreme rarity is rendered the more evident.

The section at Figtree referred to above is one of those rare occurrences which outdo textbook diagrams in clearness. There are excellent exposures along the spruit-beds, and we may see large dykes running into the schists for hundreds of yards, as well as every intermediate stage between such features and the insinuation on a microscopic scale of granitic material between the foliation planes of the schists. Sometimes the granitic and sometimes the schistose material has, owing to slight movements, been broken up into discontinuous threads. Thus we see one rock forming a matrix enclosing a series of lenticles of the other, and subsequent diffusion of material, or possibly actual melting, has in some cases also led to the formation of typical banded gneisses, while epidosites are also found, due no doubt to what Dr. Callaway calls 'secondary injection.' When once a section like that described has been seen, it is easy to interpret more obscure ones in other places. Not that other sections are necessarily obscure at all; in fact, when the unfamiliarity has been overcome, it is an easy matter from the nature of the rocks to predict the proximity of granite when crossing a metamorphic area, or of schists when traversing an igneous one. In a number of localities it is very interesting to trace the gradual changes that take place. Starting, for instance, from beyond the Rifle Kopje at Bulawayo, we begin with coarsely crystalline, unfoliated 'epidiorites,' which, in spite of amphibolisation, etc., retain an ophitic structure, which puts their original nature beyond doubt. Approaching the granite going nearly west,

[1] "Geology of South Africa," 1905, p. 98.

the rocks become more and more foliated in appearance, then igneous material begins to show between the folia, and we come to half-igneous, half-metamorphic 'banded gneisses' at what we may take as the junction. Inside the igneous mass huge fragments of what was originally schist may often be seen, which by fusion and impregnation, in the absence of stirring movements, fully bear out Professor Cole's contention that "masses of quartz-diorite arise as products of admixture where granite intrudes into more basic masses."

Of course, normal contact rocks are seen where the old sedimentaries are invaded, but from what has been said on the question of relative age, it will be inferred that this is comparatively rare. I have nevertheless been able to record from time to time the presence of nearly all the characteristic contact minerals, like andalusite, fibrolite, kyanite, cordierite, etc., chiefly from 'Banded Ironstone' junctions. But the granite masses have kept as a rule well within bounds, and rarely break through their covering of the old Basement schists or those of igneous origin. But in the absence of actual invasion by a granite mass, it is fairly obvious whether or no the latter must be regarded as intrusive. The usual intense folding of the schists leaves little room for doubt as a rule, for rocks involved in movements which have left the granite undisturbed must necessarily be of greater age.

I am afraid some of the points discussed above may be regarded as of a rather obvious nature. My excuse for putting them into writing must be that they are seldom referred to in geological works and are almost persistently overlooked in dealing with the structure of metamorphic areas.

IV.—The River Cefni in Anglesey.

By Edward Greenly, F.G.S.

MANY years ago, when discussing the origin of the Menai Straits, attention was drawn by Ramsay to the existence of several other valleys running in the same direction, north-east and south-west. Not only is this the case, however, but the valleys of the dominant system that traverses the plateau of Anglesey have the same trend, ridge and trough alternating with wonderful regularity, as far, at any rate, as Llanerchymedd, a distance of some 12 miles from the Straits.

Much less conspicuous, for the most part, though more numerous than at first sight appears, are certain valleys running at right angles to those of the dominant system, and therefore north-west and south-east. They may drain either to north-west or south-east. They are unlike those of the dominant system in almost every particular. Those are long and straight: these are short and sharply winding. Those are broad and relatively shallow, these narrow and relatively deep. Those are generally bounded by gently sloping sides, these by steep and even precipitous sides. Much the

largest is that through which the railway has been taken, just beyond the little market town of Llangefni.

The River Cefni is the name given to a very complicated system of streams, which, with all its branches, drains some 60 square miles of the interior of Anglesey. Entering the great hollow of the Malldraeth Marsh, which, as is well known, belongs to the dominant system, on its north-west side, at a point about a mile below Llangefni, the combined waters then turn round to the south-west, and find their way out to sea in Malldraeth Bay.

The Malldraeth Marsh is practically at sea-level, and until the year 1788[1] was flooded by the sea at spring tides. It was then reclaimed, and the river embanked and straightened for a distance of some six miles from its mouth; but the deserted meanders of the old river can be traced in many places as a series of stagnant, crescent-shaped pools along the alluvial plain.

Between the Marsh and Llangefni the river runs a little east of south in a comparatively open valley, chiefly cut in Carboniferous rocks. But at Llangefni it emerges, rather suddenly, from a ravine, which is excavated in schists and quartzites of the ancient complex, with a general N.E.–S.W. strike. This ravine extends for about $1\frac{1}{4}$ miles, almost exactly north-west, and is the most striking valley of the kind in the island. It is 140 feet deep at the wood's end by Pandy,[2] and in places less than 400 feet wide at the top, with precipitous and rocky sides, and it describes bold and sweeping curves in its course. In short, it is a perfectly typical water-cut valley, and differs in the most striking manner from the valleys of the dominant type.

But, at its upper end, instead of proceeding from an upland hollow in the same direction, we find that it issues, almost at right angles, from the side of a N.E.–S.W. valley of the dominant type, which extends for several miles to right and left of the exit.

Now this hollow, which may be called the Trefollwyn Valley, after a farmhouse in it near the railway, does not open out to the south-west like the Straits, the Malldraeth, and most others of the class. It is a closed oval basin, and its waters all converge to the head of the Cefni Ravine, and pass out that way at a point midway along its south-east side.

The further upper waters are very complex, and raise problems of their own, which cannot be dealt with in this paper, and which, indeed, I do not feel that I understand. But the anomalous system here described seems to throw some light on the relation of the two types of valley and their mode of origin. For the Trefollwyn Valley could not have been in existence when the Cefni Ravine was in course of excavation. Its south-west barrier, at Tai Mona, on the Holyhead Road, is less than 150 feet above sea-level,

[1] Information kindly supplied by Mr. Thomas Prichard, of Llwydiarth Esgob, Anglesey, from the records of the Drainage Commissioners.

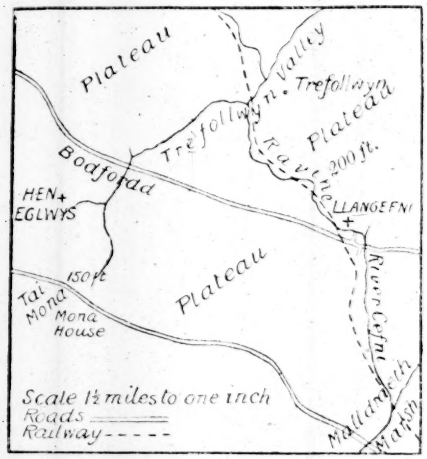
[2] I am indebted for this measurement to the kindness of Mr. Tobias Clegg, F.G.S., of Llangefni County School, who very ingeniously determined it by means of a kind of extemporized theodolite.

whereas the highest part of the plateau trenched by the Ravine is about 200 feet (see Map), so that the waters of a lake lying in the basin would have chosen the south-west exit and deepened that channel.

Nor can we postulate in this case an ice-dam such as those that have been appealed to with such striking success in Cleveland and other regions. There is not the smallest evidence of such a dam, the glaciation being steadily from north-east to south-west, with mere local variations of direction.

All the evidence goes to show that the Trefollwyn Valley is the later.

Now, nearly opposite to the exit at the Ravine's Head, a small stream enters the Trefollwyn Valley on its further side, after a course of about a mile from the north-west. It has no name on the maps, but the railway has been carried quite near to its south-west banks. It is cut in rock, not merely in drifts.



Sketch-map of part of course of River Cefni.

This channel is in the natural position for the apparently vanished upper portion of the Cefni. The fall would be slight, but there would be a fall, enough to make such a continuation possible, and ample if we allow for cutting back as well as cutting down of the lower part of the course. How, then, did it come to be so strikingly severed from its lower portion by the broad valley of Trefollwyn?

Admitting that 'subsequent' tributaries of the Cefni may have initiated that hollow, it is not easy to see how, with so short a course and so slight a fall, especially from the south-west (if, indeed, there was not a fall *to* the south-west, which seems much more likely), they could have produced one of such dimensions, for it is both deep[1] and broad.

[1] It is floored by alluvium, and its real bottom may even be below the level of the rock at the exit.

Nor does underground structure help us in any way. Though it is likely enough that there may be some fault or line of weakness along the hollow, there is certainly none of any importance.[1]

Let us consider the relation of the two valley systems to the greatest of Post-Tertiary events, the Glacial Period. The valleys of the dominant system coincide, as is well known, with the general direction of glaciation, and contain abundance of Glacial Drift. They are either of Glacial age or older, and if we admit the possibility of glacial erosion, may have been produced by the ice, as was suggested by Ramsay, or, at any rate, deepened and enlarged by it.

The Ravine, lying directly across the path of the ice, cannot have been produced by it, and must be either Pre- or Post-Glacial. It must therefore be Pre-Glacial, as we have seen that it must be older than the Trefollwyn Valley. Confirmation of this is found in the presence in its bottom of Boulder-clay, undisturbed as far as I can see, at the south point of the great bend west of Pandy.

The Cefni, then, is a Pre-Glacial river.

If now we suppose that it received two small 'subsequent' tributaries from north-east and south-west, which met near the farmhouse of Trefollwyn, and that their combined hollows were deepened and greatly widened by glacial erosion to form the large valley of that name, we shall be able to understand the severance of the two portions of the Pre-Glacial Cefni, the production of the curious closed oval hollow, and the anomalous configuration and drainage of the present day.

Indeed, it seems probable that in Pre-Glacial Anglesey the drainage to north-west or south-east was much more continuous and systematic than it is now, and that the history of the present anomalous drainage cannot be understood without reference to the events of the Glacial Period.

A curious and very interesting consideration in connection with the ancient river Cefni is that, in the earlier stages of its history, far back in Pre-Glacial time, there must have been a fine waterfall close to where is now Llangefni Station. For, at that point, the river has cut through a lenticular band of very hard quartzite, about 100 feet thick, which is conspicuous from the Station, as of it are composed the white crags below the fir-trees just opposite. Resisting erosion much more strongly than the schist on either side of it, it gives rise, even now, to a rapid. In the early stages of erosion this rock, while freely allowing the river to cut *back* to it from below, must have retarded cutting *down* in its rear for a very long time: and consequently for long ages a fine cataract must have poured over a crag some 80 or 100 feet in height. Like Gray's flower in the famous Elegy, it came into being, and then dwindled gradually away, unwatched by any but the old wild beasts, and perhaps by some men almost as wild.

[1] A fault which partly coincides with the course of the Cefni between the town and the marsh does not pass into the Ravine, but somewhat to the eastward.

REVIEWS.

I.—The Extinct Animals of Egypt. A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt, based on the Collection of the Egyptian Government in the Geological Museum, Cairo, and on the collection in the British Museum (Natural History), London. By Charles William Andrews, D.Sc., F.R.S. Printed by order of the Trustees of the British Museum, 1906. 4to; pp. xxxviii and 324, with a photogravure page frontispiece of the skull of *Arsinoitherium Zitteli*, 99 figures in the text, and 26 quarto plates. (London: sold by Dulau & Co., 37, Soho Square, W., and other Booksellers. Price 35*s*.)

AMONG recent discoveries in palæontology none have excited more interest than the Lower Tertiary Vertebrate faunas of the Fayûm. They add so much to our knowledge of the primitive Mammalia, especially of the Hyracoidea, Proboscidea, Sirenia, and Cetacea, that an exhaustive account of them, so far as discovered, had become essential. The Trustees of the British Museum have therefore availed themselves of the generous co-operation of the Egyptian Government to produce a Descriptive Catalogue of all the more important fossils by which these ancient faunas are at present known. The collection now in the Geological Museum, Cairo, was made by Mr. H. J. L. Beadnell under the direction of Captain H. G. Lyons, F.R.S., Director-General of the Egyptian Surveys, while that in the Geological Department of the British Museum was made partly by Dr. C. W. Andrews, the author of this Descriptive Catalogue, and partly by donation of duplicates from the Egyptian Government. During the past four years Dr. Andrews has had the opportunity of studying both these collections in detail, and has himself enjoyed the rare pleasure of assisting in the extraction of many of the specimens from the matrix in the Fayûm. The result is the present valuable monograph, which testifies alike to the ability of the author and the wise generosity of the Trustees in instigating its publication.

The Fayûm, the lake-province of Egypt, is a district occupying a depression in the desert to the west of the Nile Valley opposite Wasta, a small town about fifty-seven miles south of Cairo. This depression, which is roughly circular in outline, is separated from the river-valley by a belt of desert varying in width from about a mile and a half to some six or seven miles, and crossed at one point by a canal, the Bahr-el-Yusef, which runs through a narrow strip of low ground, and is practically the only source of water-supply for the whole district. The water thus brought in from the Nile is distributed by irrigation canals to the cultivated part of the district, and the surplus eventually finds its way through a number of channels, some of which form picturesque gorges, to the lowest part of the depression, occupied by a large expanse of brackish water, the Birket-el-Qurun. This lake is about twenty-five miles long, with a maximum width of only

six miles; it is very shallow, the maximum depth at present being about sixteen or seventeen feet, and its shores in most places are very low and gently sloping. In Pleistocene times the floor of the depression was occupied by a body of water of vastly greater area than the present lake, evidences of its former extent being found in the widely spread lacustrine deposits, chiefly clays, containing in addition to numerous Mollusca, remains of *Elephas africanus*, *Hippopotamus*, *Bubalis*, *Canis*, together with those of Crocodiles, Chelonians, and Fishes. In one or two places also numerous stumps of trees of considerable size occur, indicating that in some parts, at least, in the neighbourhood of the water the country was wooded. Later, within the historic period (2778 B.C.), the lake was converted into an artificially controlled reservoir, Lake Mœris, and was employed to regulate the supply of water in years of exceptionally high and low Nile floods. At this date, though smaller than the earlier Pleistocene lake, the water-covered area was far greater than at the present time, indications of its former extent being found in old shore-lines, still fringed with the stumps of tamarisk bushes, and in the ruins of temples and cities. These remains are now separated from the water by miles of desert. Later still, probably in Ptolemaic times, the lake ceased to be used as a reservoir, and the quantity of water admitted to the Fayûm was limited, so far as possible, to the amount actually required for the irrigation of the district.

A page-size geological map, reproduced from Mr. H. J. L. Beadnell's Report on the Topography and Geology of the Fayûm Province (Survey Dept. Cairo, 1905), is added at p. vi of Dr. Andrews' Introduction, on which report the geological sketch given by him is mainly founded.[1]

With only one or two exceptions, the whole of the vertebrate remains described in the present volume are derived from the Middle and Upper Eocene deposits lying on the northern side of the lake. The list comprises:—

MAMMALIA.

Arsinoitherium, 2 species.
Saghatherium, 4 species.
Megalohyrax, 2 species.
Moeritherium, 4 species.
Palæomastodon, 4 species.
Phiomia serridens.
Barytherium grave.
Ancodon, 3 species.
Rhagatherium ægyptiacum.
Geniohyus, 3 species.
Eosiren libyca.
Hyænodon sp.
Pterodon africanus.
Apterodon macrognathus.
Sinopa ethiopica.
Zeuglodon, 2 species.
Prozeuglodon atrox.

AVES.

Eremopezus eocenus.

REPTILIA.

Crocodilus, 3 species.
Tomistoma, 3 species.
Psephophorus eocenus.
Testudo, 3 species.
Thalassochelys libyca.
Podocnemis, 2 species.
Stereogenys, 2 species.
Gigantophis garstini.
Pterosphenus schweinfurthi.

PISCES.

Fajumia schweinfurthi.
Sacnopæa grandis.
Pristis fajumensis.
Propristis schweinfurthi.
Eopristis reinachi.
Aëtobatis sp.
Carcharodon sp.

[1] See also "The Geology of the Fayûm Province of Egypt": GEOL. MAG., 1905, p. 516.

Taking the collections in the British Museum and in the Geological Museum at Cairo as a whole, we find that both in point of numbers and interest the Mammals are by far the most important; next to these come the Reptiles, while the Birds are represented by mere fragments of a single species. The Mammals fall under three sections—(1) those truly endemic to the Ethiopian region; these occur both in the Upper and Middle Eocene beds, and include such genera as *Mœritherium*, *Palæomastodon*, *Arsinoitherium*, *Barytherium*, *Megalohyrax*, *Saghatherium*, and perhaps *Geniohyus*; (2) forms of which close allies occur in other regions in approximately contemporary deposits; these, so far as at present known, occur only in the Upper Eocene beds, and include such genera as *Ancodon*, *Rhagatherium*, *Hyænodon*, *Pterodon*, *Apterodon*, and *Sinopa*; (3) the aquatic Mammals so far not found in the Upper Eocene beds, and comprising *Eosiren*, *Zeuglodon*, and *Prozeuglodon*. It seems probable that some of these last, like the genera included in section (1), are of endemic origin, having originated from land-mammals inhabiting the region. Of the Subungulates, by far the most striking of the new forms is *Arsinoitherium*, first discovered by Mr. Beadnell in 1900, and since found in considerable numbers, so that nearly all parts of the animal are known, and a complete figure of the skeleton is given on p. 60, $\frac{1}{16}$ nat. size. Figures of the great bicorned skull were given in the Geological Magazine for 1903, Plates XXIII and XXIV.

In general appearance *Arsinoitherium* must have been somewhat like a large and heavily-built Rhinoceros, with two pairs of horns, the larger pair upon the front of the head and the smaller ones behind. Unlike the horns of Rhinoceros, these were solid bony outgrowths of the skull, although most likely they were, in life, sheathed in horn. The muzzle was very narrow, and not suited for grazing, and the animal probably browsed on low bushes and herbage, grasping its food by means of a prehensile tongue or by a mobile extension of the snout as in the Tapir. The height from the ground to the back in the skeleton did not exceed 6, or in life $6\frac{1}{2}$ to 7 feet. Although *Arsinoitherium* is certainly the most extraordinary of the Ungulates found in these beds, the remains of the primitive members of the Proboscidea are perhaps of greater scientific interest, as they help to fill, at least to a large extent, one of the most obvious gaps in our knowledge of the extinct Mammalia.

Previous to their discovery the earliest Proboscideans known were from the Lower Miocene of Europe and North Africa, no other earlier deposits yielding any trace of them. It had been suggested by Tullberg and others that Africa was a centre of mammalian radiation, and among other groups that the Proboscidea probably migrated thence in the early Miocene.

The researches of Dr. Andrews have proved that the earliest traces of land animals from the Eocene of Africa include remains of *primitive* Proboscidea as well as early forms of Hyracoidea, Sirenia, and perhaps some other groups.

The earliest known form of Proboscidean was *Mœritherium* from the Middle Eocene extending to the Upper Eocene. The animal

was about the size of a Tapir, and had a nearly complete Eutherian dentition.

This was followed in point of time by *Palæomastodon*, represented by four species, the largest, *P. beadnelli*, being about the size of a half-grown Indian elephant. The next form, *Tetrabelodon angustidens*, preceded the advent of the *Mastodon*, which, in its turn, was replaced by the true elephants of later Tertiary and modern times.

The position of *Barytherium* in relation to the other Ungulates is still uncertain. It suggests relationship to *Uintatherium* and to the Pyrotheriidæ, but more remains are probably needed in order to speak with certainty as to its affinities.

In the Fayûm the Sirenia are represented by one genus only, *Eosiren*, but in the earlier Mokattam Hills, near Cairo, other and more primitive types occur. There seems considerable evidence in favour of de Blainville's view that they are intimately related to the Proboscidea.

Dr. Andrews has also worked out some interesting details in regard to the Zeuglodonts of the Fayûm. These, taken in connection with a species *Protocetus atavus* (described by Professor E. Fraas) from the limestone of Mokattam, form a complete transitional series, as regards their dentition, from the Creodonts to the true Zeuglodonts. In *Prozeuglodon* the canine is distinctly larger than the teeth before and behind it, and the premolars have inner buttresses, supported by a third root.

Numerous figures and descriptions of Egyptian Vertebrates have already appeared in the Geological Magazine; namely, in 1902, pp. 433–439, Pl. XXI; 1903, pp. 225, 337, 529, 531; 1904, pp. 109, 157, 211, 481, 528; 1905, p. 562. It is not therefore necessary to enter more fully into details concerning them here.

The work is illustrated by a fine series of 26 quarto plates (and a frontispiece of the skull of *Arsinoitherium*); and, what is also of very great value, no fewer than 98 very carefully prepared text-figures giving most accurate details of the bones, teeth, and parts of the skeletons, by Miss G. M. Woodward, whose name also appears on fourteen of the plates, the remainder being executed by Mr. A. H. Searle and Mr. J. Green.

In conclusion, we must express our admiration for the way in which the author has completed this very splendid monograph, the outcome of long and careful study of the great series of remains obtained during four Winters spent by himself in the Fayûm, in addition to those obtained by Mr. H. J. L. Beadnell for the Egyptian Geological Survey, which are likewise incorporated in the present work. The Trustees of the British Museum, the Egyptian Government, and the Survey Department may also be congratulated upon the successful issue of this joint memoir, which will undoubtedly greatly advance our knowledge of the evolution of the Tertiary Vertebrates, more especially of the Proboscidea, the Sirenia, and the Zeuglodonts, whose past history was so obscure.

II.—The Great Felines of the French Caves.

Marcellin Boule. Les grands Chats des Cavernes. Annales de Paléontologie, vol. i (1906), pp. 69–95, with 12 text-figures and 4 plates.

As an introduction to this excellent memoir the comparative osteology of the lion and tiger is given, accompanied by very useful outline figures of the characteristic parts. Then follows the description of the large Pleistocene Feline from French caverns, of which the Paris Museum has no less than three skeletons, two of them, the Vence and the Cajarc skeleton, complete, and each made up of the bones of the same individual. The view of some palæontologists, that the large Pleistocene Feline of European caves was the tiger, is discarded; nor does the author consider it to form a separate species; he unites it with *Felis leo*, of which it is considered to be a race (*spelæa*). The skeleton from Vence presents some slight characters of its own; the skull has the 'leonine' characters exaggerated, and the limbs are heavier than usual. Professor Boule calls it *Felis leo*, var. *Edwardsi*, being of opinion that it seems to belong to an earlier stage of the Pleistocene than the other cave lions, and that it might therefore be considered as their ancestral form. We fail to find in the memoir the proofs for the contention of a remoter age for the Vence skeleton.

The memoir concludes with a chapter on the geographical and stratigraphical distribution of the cave lion, accompanied by a map. *Felis arvernensis*, from the Pleistocene of France and Italy, seems to be the ancestral form of the cave lion.

The new *Annales de Paléontologie*, edited by Professor Boule, in the first volume of which the present memoir is published, are a welcome and necessary addition to the existing palæontological periodicals.

III.—Descriptions of New Species of *Testudo* and *Baëna*, with Remarks on some Cretaceous Forms. By Lawrence M. Lambe, F.G.S., F.R.S.C. (Reprinted from the *Ottawa Naturalist*, January 6th, 1906, pp. 187–196, 2 plates.)

I. THE specimens of *Testudo* described in this paper were collected by Mr. Lambe, along with other vertebrate remains, in 1904, in the Oligocene deposits at Bone Coulée, Cypress Hills, Assiniboia. They were found separately, but appear to belong to one species, hitherto undescribed, for which the name *exornata* is proposed.

The three specimens upon which this species is based consist of the proximal end of the left 1st costal, the distal half of the left 5th costal, and the proximal end of the left 6th costal. All the specimens have a grooved surface, the grooves of the left 1st costal being concentric, and indicating an epidermal shield pattern such as is found in some modern species of *Testudo*. The specimens also show that the costal plates were alternately narrow and broad

distally, and broad and narrow proximally, a common character of *Testudo*. The peculiarity of the species is the extreme narrowness and thickness of the 5th costal plate.

II. The specimens of *Baëna* were first briefly described by Mr. Lambe in "Contributions to Canadian Palæontology" (vol. iii, 4to, pt. 2, 1902, Geological Survey of Canada)—"On Vertebrata of the Mid-Cretaceous of the North-West Territory." They were there referred to *Baëna Hatcheri*, Hay, from the Laramie of Converse County, Wyoming. Further study of the material has led the author to a different conclusion, and he now regards these specimens as belonging to a new species, to which he assigns the name *pulchra*. They were collected by him in the Belly River (Judith River) Beds of Red Deer River, Alberta, near the mouth of Berry Creek. They consist of the anterior half of the crushed carapace, with the entire plastron of a single individual, and of the anterior half of the plastron of another individual of slightly larger size.

Critical remarks are made upon other species of Chelonia from the Belly River series in Canada, viz., *Trionyx foveatus*, Leidy; *T. vagans*, Cope; *Adocus lineolatus*, Cope; *Basilemys variolosus*, Cope; *Baëna antiqua*, Lambe; and *Neurankylus eximius*, Lambe. Three other species from the same horizon are also referred to; these are *Plastomenus coalescens*, Cope; *P. costatus*, Cope; and *Compsemys ogmius*, Cope. A. H. F.

IV.—Fossil Flying Fishes.

Fossile Flugfische. By O. Abel. Jahrb. k.k. geol. Reichsanst., vol. lvi (1906), pp. 1–88, pls. i–iii, text-figs. 1–13.

DR. ABEL has recently made an exhaustive study of the ganoids with large pectoral fins occurring in the Trias of Austria, Germany, and Italy. He has arrived at the conclusion that their outward shape was very similar to that of the existing 'flying fishes' of the genus *Exocœtus*. He has therefore been led to prepare an elaborate memoir on 'flying fishes' in general, treating them both from the geological and from the biological point of view.

Thoracopterus Niederristi, the 'flying fish' of the Alpine Trias, was discovered long ago, but Dr. Abel has had the opportunity of adding much to our knowledge of its structure. He shows that the fins are arranged exactly as in the modern *Exocœtus*, with the lower lobe of the deeply forked tail distinctly larger than the upper lobe. At the same time he agrees with the determination of the British Museum Catalogue, that the fish is merely an aberrant member of the family Pholidophoridæ.

Thoracopterus is covered with regular rows of rhombic ganoid scales, but Dr. Abel now describes for the first time a contemporaneous fish of nearly the same shape, which is characterised by at least partial absence of scales. This new genus and species, named *Gigantopterus Telleri*, is founded on a well-preserved specimen about seven inches in length from the Upper Trias of Lunz.

The imperfectly-known *Dolichopterus volitans*, from the Upper Muschelkalk of Jena, is then discussed by Dr. Abel, who proposes the generic name *Dollopterus* to replace *Dolichopterus*, which is preoccupied.

A consideration of the so-called 'flying fishes' of the Chalk (*Chirothrix*) leads Dr. Abel to believe that they did not use their fins for skimming through the air. He gives reasons for supposing that they were inhabitants of deep water. He then discusses the whole question of the enlargement of fins, and their adaptation to 'flight' in particular, giving ample references to biological literature. The memoir is, indeed, a model of thoroughness in palæontological work.

V.—Indian Permo-Carboniferous Reptiles, Fishes, and Plants. Geological Survey of India: Palæontologia Indica. New Series, vol. ii, Memoir No. 2: Permo-Carboniferous Plants and Vertebrates from Kashmir. By A. C. Seward, F.R.S., and A. Smith Woodward, LL.D., F.R.S. pp. 1–13, 3 plates. 8vo. Calcutta, 1905.

THE brief contribution to Indian palæontology contained in this memoir is of great interest, for the discovery in 1903 by Dr. Noetling of *Gangamopteris*, associated with the typically Lower Permian fish and Labyrinthodont remains here described, has a most important bearing upon the geological age of the Lower Gondwana beds in the Peninsula of India.

The shales containing the fossils occur at a place called Khunmu, in the Vihi valley, fifteen miles south-east of Srinagar. They are overlain in the section examined by Dr. Noetling by beds containing *Fenestella* and other Polyzoa, and these are succeeded by limestones holding such characteristic Salt Range fossils as *Spirifer Derbyi*, *Productus Indicus*, etc. It should be mentioned that above the plant-bearing shales there is a break in the exposures caused by talus deposits; but Dr. Noetling's opinion was that there was no evidence of a hidden fault that could have brought the Permian limestones into their apparent position above the plant-bearing beds.

The acceptance of this view involved the important conclusion that the so-called *Glossopteris* flora existed in India in Permian times, and that instead of the Lower Gondwanas being of Jurassic age, they represent approximately the Permian of Europe. Mr. Seward, in summing up the evidence regarding the geological position of the Khunmu plants, would put it "at least as low as the Talchir series," and not improbably as corresponding with the Lower Permian or even with the Coal-measures of the Northern Hemisphere.

The plant material available, which was very fragmentary, yielded to Mr. Seward's investigations only a single generic type, *Gangamopteris*, to which he has given the appropriate specific name *Kashmirensis*. A fragment of another frond is referred doubtfully to *Psygmophyllum*.

The fish remains are assigned by Dr. Smith Woodward to two species of *Amblypterus*, viz. *A. Kashmirensis* and *A. symmetricus*.

which are very closely related to the type species *A. latus*, from the Lower Permian of Rhenish Prussia, but have relatively smaller dorsal and anal fins.

The Labyrinthodont fragments belong to the genus *Archegosaurus*, and are referred to a new species, *A. ornatus*. One specimen consists of a portion of a head; the other (belonging to a smaller individual) includes remains of the rachitomous vertebral column, with the characteristic ribs.

The plant and vertebrate remains described in this memoir are made the more easily intelligible by the three excellent plates which illustrate it. A. H. F.

VI.—Permo-Carboniferous Foraminifera of Australia.

A Monograph of the Foraminifera of the Permo-Carboniferous Limestones of New South Wales. By Frederick Chapman, A.L.S., F.R.M.S., National Museum, Melbourne, and Walter Howchin, F.G.S., Adelaide University. 4to; pp. i–xvi and 1–22, with 4 plates. (Sydney: W. A. Gullick, 1905.)

Professor T. W. Edgeworth David, of Sydney, gives an introductory account of the two distinct and widely distant horizons which have yielded the Foraminifera described in this Monograph. The Upper or Wollong foraminiferal horizon belongs to the Branxton stage of the Upper Marine series, at about 2,300 feet above the Greta Coal-measures, and the Lower or Pokolbin horizon belongs to the Lochinvar stage of the Lower Marine series, at about 1,700 feet below the Greta Coal-measures.

A diagram in the text, at page xvi, shows the relative position of these two special horizons, and of the Greta Coal-measures, in the succession of strata in the Hunter River district, New South Wales.

At Pokolbin the Foraminifera occur in an earthy limestone, with scattered particles of volcanic rock and numerous well-preserved Fenestellidæ. This deposit was probably formed on the shores of high volcanic islands, which became gradually submerged, with successive margins of conglomerate, sandstone, and pebbly shales; these passing upwards into foraminiferal calcareous sandstone or earthy limestone. Over the Pokolbin limestone occur about 2,000 feet of sandy shale, with thin Ostracod limestones. Then the Farley Sandstone for about 1,000 feet, with occasional glacial erratics; and then about 200 feet of sandstone, shales, and fire-clays, with two seams of coal (Greta Coal-measures). Marine conditions supervened, represented by pebbly beds, sandstone, and mudstone; the uppermost constitute the Muree Beds with *Strophalosia*. At 200 feet below this and 2,500 feet above the Greta Coal-measures is found the Wollong horizon, with very fine Foraminifera, Corals (*Trachypora*), and some Fenestellidæ.

The above-mentioned deposits constitute part of the great succession of strata formerly regarded as the old Carboniferous system; but,

The imperfectly-known *Dolichopterus volitans*, from the Upper Muschelkalk of Jena, is then discussed by Dr. Abel, who proposes the generic name *Dollopterus* to replace *Dolichopterus*, which is preoccupied.

A consideration of the so-called 'flying fishes' of the Chalk (*Chirothrix*) leads Dr. Abel to believe that they did not use their fins for skimming through the air. He gives reasons for supposing that they were inhabitants of deep water. He then discusses the whole question of the enlargement of fins, and their adaptation to 'flight' in particular, giving ample references to biological literature. The memoir is, indeed, a model of thoroughness in palæontological work.

V.—Indian Permo-Carboniferous Reptiles, Fishes, and Plants. Geological Survey of India: Palæontologia Indica. New Series, vol. ii, Memoir No. 2: Permo-Carboniferous Plants and Vertebrates from Kashmir. By A. C. Seward, F.R.S., and A. Smith Woodward, LL.D., F.R.S. pp. 1–13, 3 plates. 8vo. Calcutta, 1905.

THE brief contribution to Indian palæontology contained in this memoir is of great interest, for the discovery in 1903 by Dr. Noetling of *Gangamopteris*, associated with the typically Lower Permian fish and Labyrinthodont remains here described, has a most important bearing upon the geological age of the Lower Gondwana beds in the Peninsula of India.

The shales containing the fossils occur at a place called Khummu, in the Vihi valley, fifteen miles south-east of Srinagar. They are overlain in the section examined by Dr. Noetling by beds containing *Fenestella* and other Polyzoa, and these are succeeded by limestones holding such characteristic Salt Range fossils as *Spirifer Derbyi*, *Productus Indicus*, etc. It should be mentioned that above the plant-bearing shales there is a break in the exposures caused by talus deposits; but Dr. Noetling's opinion was that there was no evidence of a hidden fault that could have brought the Permian limestones into their apparent position above the plant-bearing beds.

The acceptance of this view involved the important conclusion that the so-called *Glossopteris* flora existed in India in Permian times, and that instead of the Lower Gondwanas being of Jurassic age, they represent approximately the Permian of Europe. Mr. Seward, in summing up the evidence regarding the geological position of the Khummu plants, would put it "at least as low as the Talchir series," and not improbably as corresponding with the Lower Permian or even with the Coal-measures of the Northern Hemisphere.

The plant material available, which was very fragmentary, yielded to Mr. Seward's investigations only a single generic type, *Gangamopteris*, to which he has given the appropriate specific name *Kashmirensis*. A fragment of another frond is referred doubtfully to *Psygmophyllum*.

The fish remains are assigned by Dr. Smith Woodward to two species of *Amblypterus*, viz. *A. Kashmirensis* and *A. symmetricus*.

which are very closely related to the type species *A. latus*, from the Lower Permian of Rhenish Prussia, but have relatively smaller dorsal and anal fins.

The Labyrinthodont fragments belong to the genus *Archegosaurus*, and are referred to a new species, *A. ornatus*. One specimen consists of a portion of a head; the other (belonging to a smaller individual) includes remains of the rachitomous vertebral column, with the characteristic ribs.

The plant and vertebrate remains described in this memoir are made the more easily intelligible by the three excellent plates which illustrate it. A. H. F.

VI.—Permo-Carboniferous Foraminifera of Australia.

A Monograph of the Foraminifera of the Permo-Carboniferous Limestones of New South Wales. By Frederick Chapman, A.L.S., F.R.M.S., National Museum, Melbourne, and Walter Howchin, F.G.S., Adelaide University. 4to; pp. i–xvi and 1–22, with 4 plates. (Sydney: W. A. Gullick, 1905.)

Professor T. W. Edgeworth David, of Sydney, gives an introductory account of the two distinct and widely distant horizons which have yielded the Foraminifera described in this Monograph. The Upper or Wollong foraminiferal horizon belongs to the Branxton stage of the Upper Marine series, at about 2,300 feet above the Greta Coal-measures, and the Lower or Pokolbin horizon belongs to the Lochinvar stage of the Lower Marine series, at about 1,700 feet below the Greta Coal-measures.

A diagram in the text, at page xvi, shows the relative position of these two special horizons, and of the Greta Coal-measures, in the succession of strata in the Hunter River district, New South Wales.

At Pokolbin the Foraminifera occur in an earthy limestone, with scattered particles of volcanic rock and numerous well-preserved Fenestellidæ. This deposit was probably formed on the shores of high volcanic islands, which became gradually submerged, with successive margins of conglomerate, sandstone, and pebbly shales; these passing upwards into foraminiferal calcareous sandstone or earthy limestone. Over the Pokolbin limestone occur about 2,000 feet of sandy shale, with thin Ostracod limestones. Then the Farley Sandstone for about 1,000 feet, with occasional glacial erratics; and then about 200 feet of sandstone, shales, and fire-clays, with two seams of coal (Greta Coal-measures). Marine conditions supervened, represented by pebbly beds, sandstone, and mudstone; the uppermost constitute the Muree Beds with *Strophalosia*. At 200 feet below this and 2,500 feet above the Greta Coal-measures is found the Wollong horizon, with very fine Foraminifera, Corals (*Trachypora*), and some Fenestellidæ.

The above-mentioned deposits constitute part of the great succession of strata formerly regarded as the old Carboniferous system; but,

as many animals and plants of kinds that are characteristic of the accepted 'Permian' age are associated in these strata with the characteristic fossil fauna and flora of the 'Carboniferous' period, this composite formation of 'Carboniferous' modified by 'Permian' (in India, America, Africa, and Australia) has been widely referred to by geologists as the 'Permo-Carboniferous.' We are glad to see that in this Monograph the logically correct term 'Carbo-Permian' is used by Messrs. Chapman and Howchin. Professor David goes on to compare the foraminiferal horizons of New South Wales with those known in Tasmania and West Australia.

From the descriptive part of the Monograph (pp. 1–32), we learn that the specimens of rock and detritus collected from these two special zones yielded 14 species of Foraminifera from Pokolbin and 15 from Wollong, and that 6 occurred at both places. These 35 species are referable to the following:—

Porcellanous and Arenaceous	Miliolidæ ...	1	species.	Found at Pokolbin.
	Astorhizidæ ...	2	,,	
	Lituolidæ ...	15	,,	Found at Pokolbin and Wollong.
	Textularidæ ...	4	,,	
Hyaline ...	Lagenidæ ...	11	,,	
	Rotalidæ ...	2	,,	

These 35 species are relegated to 23 genera, all of which have long pedigrees originating in Palæozoic times. Of the species here indicated, their range in time, for the Northern Hemisphere, appears to be as follows:—1 is otherwise known only in the Recent state; 1 in beds of Tertiary age; 3 occur in Cretaceous and 3 in Jurassic rocks; 3 in the Rhætic series; 1 in the Trias; 5 are known in the Permian; 8 in the Carboniferous; and some of these last are even of Silurian age.

Thus these Australian 'Permo-Carboniferous' deposits comprehend not only Upper Palæozoic fossils, but even several characteristics of Mesozoic and Cainozoic times.

We congratulate the Geological Survey of New South Wales on the good results of having obtained the co-operation of Messrs. F. Chapman and W. Howchin in working out the natural history of the two special zones of Foraminifera in the Australian Carboniferous series. The authors of the Monograph are experienced microscopists, and have a wide knowledge of the recent and fossil Rhizopods.

Special notice is made at page 20 of (1) the relative proportions of different kinds; (2) the occurrence of the same Upper Palæozoic forms in the Southern and the Northern series; and (3) the few genera that are apparently confined to strata of the particular series; (4) nine of the Australian species are regarded as new.

A very useful bibliographical list of memoirs having reference to Permian and Carboniferous Foraminifera is given at pp. 21, 22.

Mr. Chapman has carefully drawn 40 figures for the 3 plates, and five sections of the Pokolbin rock for plate iv, in a very trustworthy manner, without any unnecessary artistic niceties.

T. R. J.

VII.—Memoirs of the Geological Survey of England and Wales. Guide to the Geological Model of the Isle of Purbeck. By Aubrey Strahan, M.A., F.R.S. 8vo; pp. 26. (London, 1906: sold by Edw. Stanford, 12–14, Long Acre. Price sixpence.)

EARLY in the present year an interesting and instructive addition was made to the collection of the Museum of Practical Geology in Jermyn Street. This was a geological model, on a horizontal scale of six inches to a mile, of the Isle of Purbeck, prepared by Mr. J. B. Jordan, under the supervision of Mr. Strahan. This model is in three separate pieces, and, in order to give the physical features due prominence, the vertical scale has been made twice as great as the horizontal. Sections are drawn on the edges of the three blocks of the model, and these sections are carried down to 660 feet below sea-level. By this means the interior geological structure as well as the outcrop features are brought to the notice of the observer.

In further illustration of this excellent piece of work a Guide to the Geological Model, compiled by Mr. Strahan, has recently been issued by the Geological Survey. This "Guide" is furnished with two plates, one being a photograph of the model, and the other a small but very clear geological map of the Isle of Purbeck, on the same scale as the photograph, each fitting lengthwise into a full-sized octavo pamphlet. In addition to these illustrations there is a page giving the sections which are drawn on the edges of the three blocks of the model, as shown on the photograph of the model (plate i).

There can be little doubt that the Isle of Purbeck and its natural prolongation along the Lulworth coast present us with one of the most interesting, and at the same time accessible, pieces of geological structure to be found anywhere. Omitting the purely Bagshot country in the northern part of the 'Isle,' where the strata are flat and much obscured by peat, etc., we have in the southern half of the Isle of Purbeck the features of a varied and, in some cases, complex stratigraphy presented to the observer. Indeed, the region from Gadcliff almost to Whitenothe is a mountain chain in miniature dissected by the sea.

Mr. Strahan has not been slow to point out the leading features in the geology of the district—the long and lofty Chalk ridge, the Wealden valley, where the softer beds have yielded more readily to erosion, and then again the resistance offered by the harder Purbeck and Portland limestones. "The scenic features due," he says, "to this sequence of hard and soft beds are reproduced wherever the strata come to the surface, no less in the narrow outcrops near Durdle and Lulworth than in the broader tracts near Swanage." The different results of subaerial and marine erosion are indicated. In the sea-coves may be found the most perfect illustration of the action of the sea upon inclined strata of unequal hardness.

The remarkable folding and faulting of the region is well shown in the Model and further explained in the Guide. Thus we have normal faults, strike-faults, step-faults, etc., and, above all, the great overthrust fault so conspicuous in its effects at Ballard Point. Here the fracture is traceable for two miles inland, where it is cut off by a cross-fault, and beyond this there is no positive evidence of its existence as a fault in connection with the Chalk ridge to the westward. The age of the several folds and the evidence of earlier folds, proving the fact of recurrent folding on permanent lines of weakness, are also discussed.

After glancing at the river system, Mr. Strahan concludes with a stratigraphical summary of the beds from the Kimmeridge Clay to the Lower Bagshots, and this may be regarded as an epitome of the several formations as developed in that district. The section dealing with the Chalk is of especial interest, since it is admitted that no reliable subdivision of the Chalk, of more than local value, is possible except on palæontological grounds. The zonal tables of Dr. Barrois and Dr. Rowe are added. The aggregate thickness of the Secondary formations is estimated at rather more than 4,500 feet in the eastern, and rather less in the western, part of the region.

VIII.—Geological Survey of Western Australia. By A. Gibb Maitland, F.G.S., Government Geologist. Bulletins Nos. 8, 9, and 11 to 20. 8vo. Perth, W.A., 1903–1905.

IT is satisfactory to observe that West Australia, which originated in the old Swan River Settlement, though the last to attain equal rank with its sister dependencies of the Australian Commonwealth, is in no way behind them in the enterprising spirit that ministers so largely to the material progress of a new country. Proof of such progress is to be found in the excellent reports, issued under the authority of the Minister of Mines, here under review. Besides these Bulletins annual "Progress Reports" have been issued since 1897 which contain information relating to the Survey administration, gold and other mining, general geology, and the all-important subject, in mining districts, of water supply. The publications encourage and enjoin the use of scientific methods to aid in the rougher and more practical side of mining work, and accordingly Mr. Gibb Maitland and his able associates have directed their principal energies to the scientific examination of ore deposits, and especially to that of the precious metal.

Mr. Maitland supplies a preliminary report on the geological features and mineral resources of the Pilbara Goldfield (1904), which had not been examined since Mr. H. P. Woodward, the then Government Geologist, reported upon it about ten years previously. This report is accompanied by geological and mining maps explanatory of the text, which runs to 110 pages. It is stated that those parts of the Pilbara Goldfield embraced in the report are, on the whole promising, the 'reefs' giving every indication of permanence.

Facilities for transport are, however, much needed, if the resources of the district are to be properly developed. The stratigraphical sequence of the district examined is for the present largely conjectural; the presence of Tertiary, Cambrian, and Archæan rocks is assumed, but with doubt.

In a later report (Bulletin No. 20, 1905) Mr. Maitland continues his examination of the Pilbara Goldfield in greater detail, describing various mining centres with their auriferous deposits. This report is illustrated with plates, textual figures, and coloured maps and sections.

Bulletin No. 11 (1903) contains Mr. Maitland's notes on the North Coolgardie Goldfield, a detailed account of the mines of this famous region, illustrated with sketch-maps. He also, with the assistance of Mr. C. F. V. Jackson, supplies in Bulletin No. 16 an account of the mineral production of Western Australia up to the end of the year 1903. This report is accompanied by a map of Western Australia, showing the goldfields and other mining districts, and the distribution of useful minerals, which include gold, silver, iron, copper, lead, tin, diamonds, coal, mica, graphite, etc.

The geological features and mineral resources of the Northampton district are dealt with by Mr. Gibb Maitland in Bulletin No. 9 (1903), which contains Appendices by Messrs. H. P. Woodward, J. Provis, and E. S. Simpson. This district was first explored by Mr. Henry Y. Lyell Brown in 1871, who was at that time Government Geologist; his report being followed in 1888 by that of Mr. H. P. Woodward, who also wrote an able report upon the copper and lead mines of the district in 1895. The principal object of attainment was the accurate mapping of certain igneous rocks (basic dykes) which might afford a guide as to the horizontal extension of the metalliferous minerals, and thus assist the operations of private enterprise.

The work of Mr. Charles G. Gibson, Assistant Government Geologist, is recorded in Bulletins 8, 12, 14, and 17. The geology and the auriferous and other mineral deposits of the North Coolgardie, Murchison, and Tilgarn Goldfields were investigated. The "Auriferous Series" of the Murchison Goldfield, which contains the gold-bearing rocks, consists of "persistent zones of schist and allied metamorphic rocks." The most profitable of the gold-bearing rocks are the greenstones, though certain quartz rocks occurring in the granite are also auriferous. Maps, plates, and textual figures accompany and elucidate all these reports.

Finally, we may note Mr. C. F. V. Jackson's reports (Bulletins Nos. 13 and 18) on portions of North Coolgardie and Mount Margaret Goldfields. These contain much detailed information concerning the geological features, mines, and auriferous deposits of the districts surveyed, with ample illustrations of all kinds, as well as maps and sections. A. H. F.

IX.—Report on Geological Explorations in the West a North-West of South Australia. Prepared under the authori of the Minister of Mines, by H. Y. L. Brown, F.G.S., Gover ment Geologist. Also Contributions to the Palæontology South Australia, by R. Etheridge, jun., Curator, Australi Museum, Sydney. pp. 1–11 and 13–17, map and plates, foli (Adelaide, 1905.)

THE records of this exploration, the principal object of which w to define the boundary and limits of the Cretaceous wate bearing area in the west and north-west portions of South Australi are put into the form of a diary as the explorer and his par proceeded slowly through the somewhat desolate country throug which their route lay. Leaving Adelaide in April, 1904, th reached their destination in August of the same year. Their journ conducted them over tablelands, plains, and downs of Mesozo (Lower and Upper Cretaceous) rocks, through which protruded intervals outliers of quartzose sandstone, quartzite, and slate, strikin N.N.W., and dipping at low angles. The presence of these outlie of Palæozoic rocks is of importance in selecting sites for boring f water, as they constitute the bed-rock of the artesian basin in t district.

Numerous bores have been struck at Stuart's Creek Station, son of which are in proximity to the natural artesian springs.

The most successful bores, not in the proximity of springs, are t J. H. Angas bore, depth 962 feet, yielding 1,400,000 gallons per dien and the New Year's Gift, depth 237 feet, yielding 300,000 gallons p diem. The depths of the other bores range from 33 to 740 feet.

At another boring, that of Lake Phillipson, bituminous shal yielding petroleum on distillation, was met with at depths of 31 and 393 feet. This boring gave favourable indications of the existen of artesian water.

The rest of the diary consists of a daily record of the distan traversed and the rocks encountered until on the 5th Augu "Charlotte Waters" was reached, where the record terminates.

A great drawback to the correct delineation of the shoreline of t Lower Cretaceous artesian area is the accumulation of sand, as san hills and sand-plains. Loam and other surface deposits also cov a large extent of the interior of the country, hiding the underlyin rocks. The Tertiary and Upper Cretaceous deposits also overl rocks of older date than the Lower Cretaceous, and owing to th level nature of the surface of the country sections showing th sequence of the rocks seldom occur. The boundaries can therefo only be laid down approximately. Boring can alone determine wha rock formations exist between the Recent and Tertiary deposits an the bed-rock.

On the return journey Mr. Lyell Brown made a collection of fossil from the Lower Cretaceous rocks at Dalhousie Springs. These wer forwarded to Mr. R. Etheridge, Curator of the Australian Museum Sydney, whose description of them is embodied in this report. Th

fossils were found in a hard limestone occurring in boulders, and embedded masses in the soft argillaceous clay and shale which is the prevailing rock formation of the neighbourhood.

The collection is "interesting from the fact that it increases the number of forms from the South Australian rocks in question by five species not hitherto recorded therefrom, and also confirms the identification of two others previously known only from scanty or imperfect material." The genera represented are the following: *Aucella*, *Inoceramus*, *Haploceras*, *Anisoceras*, *Ancyloceras*, *Crioceras*, and Nautilus (*Cymatoceras* ?). The species of *Ancyloceras* (*A. cordycepoides*) is new. A. H. F.

X.—Geological Survey of Canada. Robert Bell, M.D., F.R.S., I.S.O., etc., Acting-Director. Recent Mineral Discoveries on Windy Arm, Tagish Lake, Yukon. By R. G. McConnell, B.A. 8vo. Ottawa, 1905.

THESE discoveries proved so interesting that an examination of the district was deemed advisable. Tagish Lake forms part of a chain of long, narrow lakes, originating within the coast range of mountains and extending northward and eastward for a distance of nearly seventy miles. Windy Arm joins Tagish Lake near its head, and extends south for a distance of twelve miles. The Windy Arm mining district consists chiefly of wide valleys intersecting each other, separated by mountain ridges rising from 4,000 to 5,000 feet above the valleys. The mineral area is situated a few miles north of the great granite area of the coast range.

The rocks out-cropping along the lower part of Windy Arm consist of a wide band of crystalline limestone, followed to the south by hard slates and shales, passing in places into felspathic quartzites. This clastic series is cut off and replaced about five miles above the mouth of the Arm by an eruptive rock of a porphyritic character, exposures of which out-crop along the shores of the Arm for a distance of about five miles. The porphyrite is followed southward by strongly cleaved, dark argillites and fine-grained tufaceous sandstones, alternating with bands of conglomerates and limestone. No data sufficient to determine the age of these rocks were obtained, though they are less altered than the slates and associated rocks north of the porphyrite area. The porphyritic rock separating the two series of clastic rocks constitutes the principal metalliferous formation of the district. It crosses from Windy Arm to Bennett Lake in a band about four miles in width, and also extends some distance east of Windy Arm.

A granite area about three miles in width occurs on Lake Bennett, north of the porphyrites and associated rocks. The granite is similar in character to that of the coast range, and probably belongs to the same period of igneous activity.

The largest and most persistent mineral veins so far discovered occur in the porphyrite area.

The metallic minerals contained in the veins, the gangue of which is mainly quartz, include the following: Native Silver in small spangles, and in a wire-like form; Argentite; Stephanite; Freibergite; Pyrargyrite (ruby silver); Galena (usually highly argentiferous); Chalcopyrite; Native Copper; Malachite and Azurite (due to the leaching out of the copper in the Tetrahedrite and Freibergite); Iron Pyrite; Arsenopyrite; Pyrrhotite; Sphalerite (zinc-blende).

The most valuable product of the veins is the silver; the ferruginous portion of the vein is stated to carry also gold in remunerative quantities.

A detailed description is given of the development of the mining, the general outlook being considered exceedingly promising. The mining conditions are not unfavourable as regards the situation of the veins, cost of supplies, railway communication, and other desiderata. A. H. F.

XI.—Geological Survey of Canada. Robert Bell, I.S.O., M.D., F.R.S., etc., Acting-Director. Annual Report, Vol. XIV, Part J. Report on the Geology of a Portion of Eastern Ontario (to accompany Map-Sheet No. 119). By R. W. Ells, LL.D., F.R.S.C. 8vo; pp. 1–89, map. (Ottawa, 1904.)

THIS report concerns the geology and mineral resources of the area south of the Ottawa River, where it is bounded on the north by a line extending west from the vicinity of Arnprior to a point a few miles north of Clear Lake in the county of Renfrew, and on the south by a line east from Sharbot Lake to a point a few miles south of Smith's Falls. It embraces an area of 3,456 square miles.

The geological formations represented in the area comprised in this map-sheet are the following:—

Post-Tertiary.
Utica shales.
Trenton.
Black River.
Chazy shales and limestones.
Calciferous and Potsdam sandstone.
Mica, chlorite, and hornblende schists and amphibolites, with some conglomerates.

The most interesting part of the report is the discussion of the age of the crystalline rocks, the history of which, dating back for nearly fifty years, is very exhaustively treated, and a lucid account of the views held by the older authorities—Logan, Macfarlane, Hunt, Vennor, Selwyn—is supplied. The later work of Messrs. Adams and Barlow is also adverted to by the author, who himself began in 1891 and the three following years the detailed examination of the area north of the Ottawa, in the typical district where the rocks of the Grenville series of the Canadian geologists were first studied.

The rocks in the area surveyed are roughly divided into four groups, viz. :—

I. Granite-gneiss and syenite, which apparently represent the oldest series upon which the others rest.

II. Gneiss, sometimes highly quartzose and garnetiferous, certain portions passing upward into limestones.

III. Amphibolites with schists, sometimes micaceous, sometimes chloritic, hornblendic or dolomitic, with altered slates and true conglomerates and limestones.

IV. Granites and diorites, some of which are clearly intrusive and newer than the rocks which they penetrate.

A full description of these rocks, geological and topographical, is given under the headings "Underlying granite-gneiss series" and "Newer Limestone, schist and gneiss series."

The succeeding sections of the report refer chiefly to the economic minerals found in the area surveyed. The most important of these are iron, gold, silver, galena, nickel, mica, apatite, graphite, corundum, and felspar, besides other economic products, including building stones, brick clays, shell-marl, lime, and peat.

A short account of the glacial geology with a list of striæ is supplied, and an appendix contains preliminary lists of fossils by Dr. H. M. Ami, with some interesting notes on the fauna.

The coloured map (compiled by Mr. Joseph Keele) which accompanies the report, is drawn to a scale of four miles to the inch and has copious geological notes in the margin. A. H. F.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 4th, 1906.—R. S. Herries, M.A., Vice-President, in the Chair. The following communications were read :—

1. "On a Case of Unconformity and Thrust in the Coal-measures of Northumberland." By Professor G. A. L. Lebour, M.A., M.Sc., F.G.S., and J. A. Smythe, M.Sc., Ph.D.

The sections described occur on the coast north of the Tyne, near Whitley Sands, between Table Rocks and Briar Dene Burn. The base of the "Table Rocks Sandstone" is found to rest unconformably upon a series of alternating shales and sandstones, among which is a well-marked band of clay-ironstone crowded with *Carbonicola acuta*, one of those 'mussel bands' which are found to be perhaps the most remarkably persistent strata in the North of England Carboniferous rocks. According to the correlation of the Geological Survey, this particular band is the one that is well known as

occurring a little way above the Low Main coal-seam. The entire junction, so far as it can be seen at the base of the cliffs and on the foreshore, many parts of which are only swept clear during exceptional weather, has been studied as opportunity offered during a series of years. The unconformity is shown by discordance in dip, by overlap of the Table Rocks Sandstone, and by the existence of a pebble-bed, containing fragments of the mussel band and other parts of the underlying series, in the lower part of this sandstone. But the upper, more massive, beds in the section have been thrust in a northerly direction over the lower and more yielding beds, the plane of gliding corresponding accurately along parts of the section with the plane of erosion. Towards the north of the section the beds of the upper series are weakened by intercalated bands of shale, and then differential action has been set up. The result is that the thrust-plane is no longer a simple one coinciding with the unconformity, but extends some way above it. The effects of the thrust are seen in the ploughing up, folding, and faulting of the lower series, in the penetration of tongues of sandstone from the upper series into the lower, in the curling up and shattering of the pebble-bed, in the puckering and hardening of the shale, and in the blending of fragments of various rocks subjected to its influence. The marks of intense action are practically confined to the surface of the beds of the lower series. The action of the thrust is markedly rhythmical, and its effect is to mask the unconformity; and the great discordance in dip which is at times produced is no criterion of the unconformity. Although the amount of rock removed by intro-Carboniferous denudation from the lower series is unknown, chemical and other evidence is given to show that the lower series has undergone weathering and some leaching out of constituents in the interval between the two series.

2. "The Carboniferous Succession below the Coal-measures in North Shropshire, Denbighshire, and Flintshire." By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S., and John T. Stobbs, F.G.S.

This paper opens with a critical account of previous research among the Carboniferous rocks of North Wales, chiefly the work of the late G. H. Morton, Mr. R. Kidston, and Mr. A. Strahan. There follows a detailed account of the various beds, exposed in numerous quarries worked for road-metal, iron manufacture, lime, cement, chert, or building stone. Fossil lists are given from each exposure of importance. The lower series of the Carboniferous Limestone, as developed in the Bristol area, was never deposited in this district, where the lowest beds contain fossils characteristic of a comparatively late phase of the Carboniferous Limestone Period. Whether this was due to irregular configuration of the ocean floor of that age, or to contemporaneous earth movement of a regional character, cannot as yet be determined. The base of the limestone is characterized by *Daviesiella* (*Productus*) *llangollensis*, and appears to correspond with the junction of the Upper *Seminula* and Lower *Dibunophyllum* Beds of the Bristol area. The next limestones in

ascending succession are characterized by the presence of *Dibunophyllum* φ and *Cyathophyllum Murchisoni*, fossils which indicate, in the Bristol area, the life-zone which immediately underlies the *Lonsdalia* Beds. These two life-zones have been named by Dr. Vaughan the Lower and Upper *Dibunophyllum* zones respectively. The *Cyathaxonia* Beds and the cherts are equivalent to a zone higher than the Upper *Dibunophyllum* zone of Bristol, and not represented there. The black limestones (containing *Posidonomya Becheri*) with shales, at Teilia, Holywell, and near Bagillt, which occur above the cherts, are the homotaxial equivalents of the Pendleside Series. These beds are followed by the Gwespyr Sandstone, which is correlated with the Millstone Grit. A range-table is given of the chief brachiopods and corals, and the palæontological sequence is compared with that occurring at Bristol and in the North of England. A few notes on the palæontology conclude the paper, and Dr. R. H. Traquair appends a short description of a new species of *Elonichthys*, occurring in the Holywell Shales.

II.—April 25th, 1906.—J. E. Marr, Sc.D., F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "Trilobites from Bolivia, collected by Dr. J. W. Evans in 1901–1902." By Philip Lake, M.A., F.G.S.

Several horizons are represented by these fossils. Two specimens of *Peltura*, probably from the Upper *Lingula* Flags, were collected at Cochaiya, about 3 miles north-east of Pata. New species of *Symphysurus* and *Trinucleus*, probably of Arenig age, were found about a mile from Apolo, Province of Caupolican. An indeterminable species of *Ogygia* was obtained from the right bank of the River Caca, in the same province. *Phacops* cf. *arbuteus*, *Dalmanites Paituna*, and *D. Maecurua* were collected in the track from Apolo to San José de Chupiamonas, also in the province of Caupolican. The nodules from which they were derived are probably of Lower Devonian age. Descriptions are given of the new species and other forms mentioned. It is worthy of remark that, while the earlier forms show affinities with the contemporaneous European fauna, the Devonian species are much more closely allied to those of South Africa and North America.

2. "Graptolites from Bolivia, collected by Dr. J. W. Evans in 1901–1902." By Ethel M. R. Wood, D.Sc. (Communicated by Dr. J. W. Evans, LL.B., F.G.S.)

In black pyritic shales from three localities several specimens of *Didymograptus* were collected; one referable to *bifidus*, one of the type of *affinis*, and one of the *Nicholsoni* type. *Phyllograptus*, *Glossograptus*, *Cryptograptus*, and *Diplograptus* were also obtained. A pale, silky grey shale shows also rare graptolites, belonging to

a species comparable with *Climacograptus confertus*. These forms indicate that both the black and the pale shales belong to horizons in the Upper Arenig rocks (Lower Llanvirn of Hicks).

3. "The Phosphatic Chalks of Winterbourne and Boxford (Berkshire)." By Harold J. Osborne White, F.G.S., and Llewellyn Treacher, F.G.S.

Data collected in the district dealt with in this paper suffice to show that the more or less Phosphatic Chalks above the *Uintacrinus*-band lie in a trough or basin, the formation of which antedates the deposition of the Reading Beds. When the area of observation is extended, it is found that the *Uintacrinus* Chalk of that tract itself lies in a structural depression. In view of the development of phosphatic and of hard, rocky beds, indicative of slow and interrupted sedimentation, in the underlying *cor-anguinum* zone, it seems not unlikely that this basin is an original or inherent feature of the Chalk directly attributable to a local attenuation of that zone; but the authors believe the depression to be due mainly to differential earth movements, of which there are many indications. The exposures are found in the eastern (Winterbourne) and western (Boxford) sides of a spur lying in the angle between the converging valleys of the Lambourn and the Winterbourne. On the eastern side the following succession is recognized:—

1. Reading Beds of the Borough Hill outlier.		
2. Chalk with some flints.		Zone of *Actinocamax quadratus*.
3. Phosphatic Chalk.		
4. Phosphatic Chalk.	*Marsupites*-band.	Zone of *Marsupites*.
5. Very feebly phosphatic Chalk.	*Uintacrinus*-band.	
6. Chalk with tabular flints.		Zone of *Micraster cor-anguinum*.
7. Chalk with flints.		

and on the western side—

1. Reading Beds.		
2. Phosphatic Chalk.		Zone of *A. quadratus*.
3. Phosphatic Chalk.	*Marsupites*-band.	Zone of *Marsupites*.
4. Feebly phosphatic to normal Chalk.	*Uintacrinus*-band.	
5. Normal flinty Chalk.		
6. Phosphatic Chalk.		Zone of *Micraster cor-anguinum*.
7. Normal flinty Chalk.		
8. Phosphatic Chalk.		
9. Normal flinty Chalk.		

The maximum thickness of the Phosphatic Chalk Series is about 130 feet. Detailed accounts of the various exposures are given, as also lists of fossils from the various bands, and an account of the microscopic features of washed residue from the softer chalks of the pit a quarter of a mile north-west of Winterbourne Church. This yields: (1) pieces of *Inoceramus* shell, the majority unphosphatized; (2) foraminifera, frequently phosphatized; (3) angular chips of scales, bones, and teeth of fishes; (4) irregular, angular, or sub-angular lumps and platy pieces of calcite, probably in the main fragments of oysters; (5) rod-like objects, smooth, cylindrical, or tapered—probably spines of echinoids; (6) coprolites of small

fishes, etc.; (7) tests of entomostraca; (8) quartz in subangular and well-rounded grains; (9) black granules, apparently of iron-oxides; (10) rich-brown, polished phosphatic concretions; and (11) dull-green grains, imperfectly rounded. These constituents are enumerated as nearly as possible in order of abundance.

The Winterbourne-Boxford phosphates have a known range in time considerably greater than those of Taplow. Their advent far down in the *cor-anguinum* zone is especially interesting; for in England, as Mr. Jukes-Browne has remarked, that subdivision of the Chalk almost everywhere "presents the appearance of having been quietly and continuously accumulated in water that was seldom disturbed by bottom currents," albeit a tendency to develop hard bands at one horizon, at least, is apparent in the western part of the London Basin. The Phosphatic Chalks of Winterbourne and Taplow evidently mark places on the sea-floor particularly liable to the impingement of strong currents, and may mark places above which the water commonly had a gyratory motion. In any case, their zonal range argues a marked degree of stability in the current-system of the body of water in which they were laid down.

CORRESPONDENCE.

THE TRIMMINGHAM CHALK AS A ZONE.

Sir,—I hope you will allow me at this late hour to reply to Mr. Jukes-Browne's letter in your February number. It raises some very large questions which cannot be adequately dealt with in a letter, but I should like to define my position.

It appears to me that the term 'zone' is applied indiscriminately to at least two different conceptions. One of them is what may be labelled the 'international zone.' This covers the great ill-defined subdivisions which persist over large areas embracing more than one natural province, and by which we correlate the equally ill-defined local territorial names such as 'Norwich Chalk,' 'Maestricht Chalk,' 'Meudon Chalk,' etc. These correlations are interesting, but of little practical value, as the zones themselves are rarely, if ever, accurately defined.

The other conception above referred to is what may be called the 'provincial zone.' Each of these zones contain such a thickness of sediment as from place to place over a natural province (whether made natural by modern geographical or ancient geological conditions) contains *throughout* (*pace* Mr. Jukes-Browne) some well-marked form which is comparatively scarce or altogether absent both above and below. These zones have upper and lower limits which are well defined either palæontologically or stratigraphically, often in both ways. They are therefore capable of practical application by the pit-worker, who most stands in need of help, and through him by allied

sciences. The 'zone of *Marsupites*,' to which Mr. Jukes-Browne appeals, is one of the finest possible examples of what I mean. The 'zone of *Marsupites*,' introduced by Barrois, was an international zone. It was adopted from a country in which not much was known about it, and it had not even received a separate name; its upper boundary for England was wholly undefined, its lower boundary was only defined in the Margate area by a physical character which Barrois only thought he recognised again in the Sussex area, and there wrongly according to Dr. Rowe, and the type fossil only occurs in about 40 feet out of some 300 feet attributed to this zone by Barrois. I do, though I gather Mr. Jukes-Browne will disapprove, most strongly urge the limitation of the 'zone of *Marsupites*,' for the south of England at any rate, to the important bed of very uniform thickness and position in the series which contains *Marsupites* "in every foot," and outside which *Marsupites* is practically non-existent. Can there be any doubt as to which of these two zones is the more logical and practically useful?

Now it so happens that the international zones introduced by Barrois up to and including the zone of *M. cor-testudinarium* are sound provincial zones for the south of England, answering (except in the case of the zone of *B. plena*) very well to what Mr. Jukes-Browne considers such an unreasonable test, i.e. the occurrence of the type fossil in every foot of the zone. But that does not make it any the less desirable if we are establishing a new zone to establish the most accurately defined one that we can. Does Mr. Jukes-Browne's zone of *O. lunata* satisfy the reasonable requirements of scientific accuracy? How would he define its upper and lower boundaries? Clearly not by the appearance and disappearance of *O. lunata*, for there are at least 10 feet of chalk exposed at Trimmingham below the lowest occurrence of this species and anything from 25 feet upwards above the highest occurrence, and I cannot see any other possible criterion. The zone of '*Terebratulinæ*' which I propose begins where *Terebratulina gracilis* appears (and I am in hopes of satisfying myself that this is just above the hard yellowish bed, in which case the zone of *B. mucronata* would have at Trimmingham an upper boundary defined both physically and palæontologically), and will end where *T. gracilis* disappears, unless before that point is reached some other fossil worthy of being made a zone fossil comes in. The only objection I can see to my zone of *Terebratulinæ* will be removed when the characteristic fossil of the zone below that of *H. planus* is properly named, and I hope we shall not have to wait much longer for this.

R. M. Brydone.

16, South Audley Street, W.

[Erratum.—In Mr. R. M. Brydone's article in February number, Geol. Mag., 1906, p. 77, line 33 from top of page, for 'blending' read 'banding.'—Edit. Geol. Mag.]

OBITUARY.

PROFESSOR EUGÈNE RENEVIER,

For. Memb. Geol. Soc. Lond.

Born 26th March, 1831. Died 4th May, 1906.

With deep regret we record the death of Professor Eugène Renevier, son of a distinguished lawyer (Charles Renevier). He was born at Lausanne on the 26th March, 1831, and died, through an accidental fall from a lift, on May 4th. Towards the age of 17 he began to follow the lectures at the polytechnical school of Stuttgart, where he became intimate with Oppel. He seems to have remained for about three years at Stuttgart. In 1851 we find him doing work with Professor Pictet at Geneva, where he prepared his "Mémoire géologique sur la Perte du Rhône," published in 1854. In the same year we find him working in Paris, under Professor Hébert, on the Nummulitic deposits of the Alps.

In 1856 he began his teaching at the Lausanne Academy, starting with lectures on zoology; and in 1858 he began the teaching of geology. The present year was the fiftieth anniversary of his academic teaching, and was to have been celebrated by his friends in Lausanne with unusual honour.

In 1893 Professor Renevier presided at the Meeting of the Société Helvétique des Sciences Naturelles, convened at Lausanne. In 1894 he was President of the Sixth International Geological Congress at Zurich. He took a very active part in all the International Congresses; and from the first he was Member of the Commission for the Unification of Nomenclature.

He was the founder and, from the commencement, President of the Swiss Geological Society.

For the above particulars we are much indebted to the courtesy of Professor Maurice Lugeon, Professor of Geology in the University of Lausanne, Switzerland. C. I. F. M.

The following is a list of the principal publications of Professor Renevier (there are about 100 in all):—

Mémoire géologique sur la Perte du Rhône (Nouv. Mém. Soc. Helv. Sc. Nat., vol. xiv, 1854).

Description des fossiles du Nummulitique supérieur de Gap, Diablerets, etc. (en collab. avec Prof. Hébert) (Bull. Soc. stat. Isère, iii, et Bull. Géol. Fr., ser. II, xi, 1854).

Geological and Palæontological Notes on the Alps of Vaud:—

(1) Infralias et zône à *Avicula contorta* (Bull. Soc. Vaud. Sc. Nat., viii, 1864).
(2) Massif de l'Oldenhorn et Col de Pillon (Bull. id., viii, 1865).
(3) Environs de Cheville (id., 1866).
(4) (Avec F. J. Pictet) Céphalopodes de Cheville (id., 1866).
(5) Complément de la Faune de Cheville (id., 1868).
(6) Gisements fossilifères houillers du Bas Valais (id., 1879).

Tableaux des terrains sédimentaires (Bull. Soc. Vaud. Sc. Nat., xiii, 1874).

Structure géologique du Massif du Simplon (id., xv, 1878).

Rapport au Congrès Géol. International de Bologna sur l'unification des procédés graphiques (C.R. Congr. Bologna, 1881).